A nudge in the right direction: the role of incentives on behaviour and preferences in recreational fisheries

by

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Abstract

Marine recreational fisheries are ecologically, culturally, and economically important. However, ensuring effective management and compliance is notoriously difficult due to factors such as extensive coastlines, the sparse nature of recreational fishing, and lack of formal management infrastructure. Overcoming these obstacles is facilitated by fulfilling a wide range of objectives of recreational fisheries management. This is integral to ensuring sustainability, however, the effective management of recreational fisheries is further complicated due to diverse motivations of recreational fishing and uncertainty in fishers' behavioural responses to management changes. Understanding the behavioural aspect or human dimensions of recreational fisheries management is necessary for effective evidence-based policy making, which contributes to fulfilling the management objectives.

This thesis contributes towards more effective understanding of fishers by investigating the compliance behaviour and preferences within recreational fisheries management. Fisheries compliance literature recognises the integral role that behavioural incentives, such as social norms, morals and, legitimacy play in the compliance decision-making process. The overall objective of this thesis is to explore the role of behavioural incentives on compliance behaviour in recreational fisheries management and explore management preferences of fishers. This objective is addressed in the six subsequent chapters of this thesis.

First, a general introduction of the context of the thesis is presented (Chapter 1). Chapter 2 explores the potential of behavioural based recreational fisheries management in detail through a narrative review of the relevant literature. Specifically, it, explores the use of nudges, which are behavioural tools that aim through subtle changes and indirect suggestion to make certain decisions more salient. Chapter 3 empirically explores the influence of a descriptive social norm nudge on compliance behaviour and compares it with a traditionally used deterrence method of inspection. This is done through an economic laboratory experiment in a recreational fisheries context. The results show that the presence of descriptive social norm nudge can increase compliance behaviour but to a lesser extent than an increase in deterrence. Chapter 4 explores the results of this experiment further by investigating the relationship between behavioural drivers and compliance responses. Information for five psycho-social drivers - expectations of others' behaviour, social norms, ecological values,

personality types, and risk preferences - was collected for each participant by survey. The results highlight patterns in psycho-social drivers and behavioural responses, which vary depending on the compliance incentive method applied to encourage compliance behaviour. Chapter 5 empirically explores the management preferences within a consumptive recreational fishery in Tasmania, Australia, with the aim of identifying the preferences of heterogeneous recreational fishers. This was conducted using a combination of a discrete choice experiment and an opinion-based phone survey. Results show that homogenous preferences were related to management that had a direct impact on catch, whereas heterogeneous preferences were found around management tools that had an indirect impact on catch.

Together this research highlights several drivers of heterogeneity within recreational fishing management; from opposing responses to compliance incentives to varying psycho-social make-up within behavioural groups to divergent management preferences. The results of the research within this thesis provide empirical evidence of alternative compliance tools, such as nudges as well as drivers of different behaviours and opinions. The findings underline the importance of nuance and heterogeneity of fishers, behaviours, and drivers in the context of recreational fisheries. Knowledge of this variability encourages better integration of accurate human dimensions and can advance recreational fisheries towards innovation and increased effectiveness.

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Chapter 1- Thesis Introduction

1.1 Background

The world's oceans are under pressure from climate change (Pecl et al. 2017), overfishing (Hobday et al. 2011), pollution (Vince & Hardesty 2018) and other anthropocentric threats that demonstrate an urgent need for sustainable ocean management (Aswani et al. 2018). Marine systems are changing faster than any other period in recorded history (UNEP 2006) and large and small marine fauna have decreased in abundance due to human activities (McCauley et al. 2015). To protect the marine-provided goods and services which people depend on, sustainable management, conservation, and restoration of marine ecosystems are vital (IUCN 2017). Among many marine resource user groups, the fishing industry is one of the key industries with a responsibility to reduce marine impacts (Pauly & Zeller 2016). Many fisheries are managed under regulated open access regimes (Homans & Wilen 1997; Reimer & Wilen 2013). This may fail to fully curtail the destructive race behaviours characteristic of users of a common pool resource, which can result in excessive fishing capacity and user congestion, and overuse of fish stocks. The success of fisheries management depends on factors such as strong leadership, social capital, and incentives (Gutiérrez et al. 2011) as well as having congruent objectives (Hilborn 2007). Incorporating human behaviour into research, management and policy is pivotal to ensuring that these factors are promoted to improve marine resource management and conservation in the Anthropocene (Halpern et al. 2008; Aswani et al. 2018; Van Putten et al. 2012).

In the literature, attention towards better understanding of human behaviours has been mostly aimed at commercial or subsistence fishing (Pecl et al. 2014). Nonetheless, the importance of recreational fishing ecologically (Arlinghaus 2005), socially and culturally (Cooke & Schramm 2007; Palmer 2004), as well as economically (Steinback et al. 2004) highlight the need for behavioural research in this domain in a time of rapid global ocean change (van Putten et al. 2017). A better understanding of recreational fishers behaviours and their diverse motivations and preferences can reduce unintended outcomes of management interventions (Pine et al. 2009) and better predict and assist how recreational fisheries adapt to changing environments and evolve to maintain resilience and sustainability on a global scale (Arlinghaus et al. 2013). Human dimensions research in recreational fisheries has also demonstrated the importance of the heterogeneity in recreational fishers' motivations, behaviours, and preferences (Beardmore 2013; Matsumura et al., 2019). In fact, the heterogeneity of fishers is thought to be a key ingredient of the complex dynamics of recreational fisheries and key for better management (Post 2013).

Recreational fisheries are traditionally managed via a mixture of regulations and rules (Morison 2004). However, achieving an acceptable rate of compliance in recreational fisheries is inherently difficult

because there is often no formal mechanism to monitor and record the actions of recreational fishers (Green & McKinlay 2009). Non-compliance is a tenacious problem in recreational fisheries management, posing a risk to marine conservation and socio-ecological systems (Post et al. 2011;Blank & Gavin 2009; Arias & Sutton 2013;Smallwood & Beckley 2012). In fisheries management, deterrence-based approaches have traditionally been used to tackle non-compliance. However, sufficient monitoring and enforcement are often limited and prohibitively costly in recreational fisheries and an alternative approach is needed to improve compliance (Cooke et al. 2013). In response to this, behaviour change initiatives that are not based solely on deterrence methods are beginning to be proposed and implemented to improve compliance (Battista et al. 2018).

This thesis contributes towards more effective understanding of fishers by investigating the compliance behaviour and preferences within recreational fisheries management. Policy making to ensure compliance and contribute towards sustainable recreational fisheries management is not straightforward with dissonant and diverse objectives that are conditional on stakeholders' priorities (Aanesen et al. 2014). Fisheries compliance literature recognises the integral role that behavioural incentives, such as social norms, morals and legitimacy play in the compliance decision making process. This thesis specifically explores the role of behavioural incentives on compliance behaviour in recreational fisheries management and explores management preferences of fishers. Understanding the behavioural aspect or human dimensions of recreational fisheries management is necessary for effective evidence-based policy making, which contributes to fulfilling management objectives.

1.2 Recreational fishing

Recreational fishing is a popular recreational activity in many places around the world (Smallwood & Beckley 2012), with global estimates ranging from 220 million (World Bank et al. 2012) to 700 million recreational fishers (Cooke & Cowx 2004). There are several associated benefits derived from recreational fishing. It generates significant economic benefits to communities, for example through the flow-on economic and employment benefits arising from fisher expenditure and tourism (Cisneros-Montemayor & Sumaila 2010). For example, the total economic impact of marine recreational fishing amounts to 10.5 billion Euro, supporting almost 100,000 jobs (Hyder et al. 2017). There are physical and psychological health and social benefits from fishing (Griffiths et al. 2017), as recreational fishing is found to strengthen social ties as well as reduce heart rate and anxiety, and increase connectedness with nature (Hughes 2014). Recreational fishing has also been recognised as providing an important source of protein for fishers (Cooke & Cowx 2006; Cooke et al. 2018).

Despite various benefits derived from recreational fishing, global recreational fisheries are generally poorly understood relative to commercial fishing (Young et al. 2014). Ubiquitous to recreational fishing research is the recognition of a lack of official reported data due to limited monitoring and enforcement (Dickson et al. 2009). As a result, the scale and impact of recreational fisheries are frequently underestimated (Cooke & Cowx 2006; Lewin et al. 2006). It is estimated that recreational fisheries only account for 1 million tons of catch annually, a small proportion relative to total global catch at approximately 120 million tons (Pauly & Zeller 2016). However, the ecological impact from recreational fisheries is locally and regionally consequential (Lewin et al. 2006; Cooke & Cowx 2006) and is attributed with contributing to the global fisheries decline (Worm et al. 2009; Cooke & Cowx 2004). To reduce these impacts, recreational fisheries are typically managed by the same regulations as in commercial fisheries (Cooke & Cowx 2006). The effective management of recreational fisheries is further complicated due to diverse motivations of recreational fishers and uncertainty in fishers' behavioural responses to management changes. Motivations of commercial fishers are predominantly related to economic rewards, whereas recreational fishing is fundamentally a leisure activity and motivations vary extensively (Cooke et al. 2019; Fedler & Ditton 1994). Despite the differences in motivations, scale, and capacity, the assumption is often made that conventional commercial fisheries management methods are applicable to recreational fisheries management.

Non-compliance with regulations in the global conservation context remains one of the largest illegal activities in the world, resulting in degradation to societies, economies and the environment (Haken 2011; Arias 2015). Ensuring compliance with regulations is a key element in effective fisheries management to encourage sustainability. Due to factors such as extensive coastlines, the sparse nature of recreational fishing, and lack of formal management infrastructure, non-compliance occurs within recreational fisheries (Bergseth 2017; Bergseth & Roscher 2018). Broadly, compliance can be viewed as a function of deterrence and voluntary compliance. Deterrence is the outcome of deliberately implemented prevention tactics including the likelihood of getting caught and the severity of the repercussions. Voluntary compliance, on the other hand, occurs when people willingly choose to adhere to the rules and regulations regardless of the expected repercussions of non-compliance (Putt & Nelson 2008). For many recreational fisheries around the world where enforcement is limited or ineffective, an alternative to management based solely on deterrence – which is central to commercial fisheries - is needed to encourage voluntary compliance behaviour (Cooke et al. 2013; Arias & Sutton 2013; Arias 2015; Bergseth & Roscher 2018).

1.3 Compliance behaviour and incentives

An incentive is something that motivates an action and can be effective at changing behaviours. The importance of designing incentives for fishers to voluntary comply with regulations is well recognised (Chen 2010; Cooke et al. 2013; Read et al. 2011). Broadly, incentives can be monetary or non-monetary with various effectiveness in different contexts (Gneezy et al. 2011). Traditional perspectives on compliance assumed monetary incentives were the main driver in compliance decisions, while more socialised views have emerged with the roles of social norms, legitimacy and fairness playing a large part (Honneland 1999; Nostbakken 2013; Sutinen & Kuperan 1999). These non-monetary, or behavioural, incentives, such as the desire to reciprocate or the desire to avoid social disapproval (Fehr & Falk 2002), can also shape and encourage behaviour changes by targeting voluntary compliance.

Understanding of behavioural drivers is yet to be adequately applied in management, as harnessing social norms, legitimacy and personal morality into action is challenging. Additionally, there is a gap in the literature examining the efficacy of compliance tools based on behavioural incentives at encouraging voluntary compliance behaviour. Nudges may be an example of a behavioural incentive-based tool to encourage voluntary compliance. Nudge theory argues that through positive reinforcement or indirect suggestion, non-forced compliance can be achieved. The term 'nudge' was first coined by Thaler & Sunstein in their book *Nudge: Improving Decisions about Health, Wealth and Happiness* (2008) with a nudge defined broadly as a change to "any aspect of choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (2008;6). Choice architecture refers here to the way in which options are presented to people that in turn may influence their choice. More specifically, nudges can fall under the following categories, i) simplification and framing of information, ii) changes to physical environment, iii) changes to the default policy, and iv) use of social norms and comparisons (Mont et al. 2014; Lehner et al. 2016). The use of nudges in public policy has increased over the past decade (Benartzi et al. 2017), including examples in energy conservation and energy efficiency investments, transport choices, water conservation and sustainable food consumption (OECD 2017a; OECD 2017b). Examples specifically targeting compliance behaviour can be found in taxation (Cadsby et al. 2006; Li et al. 2011) and environmental regulation (Behavioural Insights Team 2015). While the use of nudges in marine management has been advocated for (e.g. Cvitanovic et al. 2018) there is little evidence of their application in addressing compliance issues in recreational fisheries management and they have yet to be tested in a controlled setting.

1.4 Thesis aims and structure

This thesis specifically aims to explore the role of behavioural incentives on compliance behaviour in recreational fisheries management and explores management preferences of fishers. Through this research the heterogeneity of behaviours and preferences in response to incentives can be explored. The approach adopted in this thesis is an interdisciplinary perspective drawing on behavioural and experimental economics, supplemented with contextual understanding of fisheries management and social psychology. This thesis draws on different methodologies including narrative literature reviews, empirical research using experimental data and choice modelling, to contribute to a better understanding of the behaviours and preferences of recreational fishers. This aim is explored in the five subsequent chapters.

Chapter 2 explores the potential of behavioural based management through a narrative review of the relevant literature; specifically, exploring the use of nudges, which are behavioural tools that aim through subtle changes and indirect suggestion to make certain decisions more salient, thereby improving voluntary compliance. This concept is explored with specific reference to the compliance of fishers within Australian recreational fisheries. There are only a few examples of behavioural based approaches found. However, based on their theoretical foundations, nudges may represent an inexpensive, and potentially highly effective tool for recreational fisheries management. Nudges do not offer a 'quick fix' to cases where traditional policy instruments have failed. Rather, there is the potential for behavioural nudges (based on framing, changing the physical environment, presenting default options, and social norms) to augment and complement existing deterrence regimes. Several potential nudges for compliance management in recreational fisheries are suggested, but caution is advised. As with any novel management approach, nudges must be rigorously tested to demonstrate their cost-effectiveness and to avoid unintended consequences.

In Chapter 3, we explore the lessons from behavioural economics and apply nudge theory as the basis of alternative management approaches. Nudge theory argues that through positive reinforcement or indirect suggestion, voluntary compliance can be achieved. The aim of this chapter is to test the influence of a nudge, based on a descriptive social norm, through an economic laboratory experiment in a recreational fisheries context. Social norms have been used successfully previously to promote pro-social and pro-environmental behaviour, for example to encourage voting attendance (Gerber & Rogers 2009) and energy conservation (Allcott 2009). However, to the best of our knowledge the effectiveness of a descriptive social norm in any recreational fishing context has yet to be quantified or tested. We achieve this aim by addressing the following three research questions: 1) Does the use

of a descriptive social norm nudge change the decision on the quantity of fish caught in a recreational fishery and does it influence compliance with a regulation (i.e. catch limit)? 2) Does the effect of a descriptive social norm nudge depend on the level of traditional deterrence-based interventions in place? 3) Do individuals' preference for risk affect compliance behaviour in the presence of a descriptive social norm nudge?

Within Chapter 4 the results from Chapter 3 are further explored. While we know that in fisheries people make trade-off decisions between following or breaking rules, it is of interest to determine how people respond to different management incentives. The overall aim of this chapter is to examine what psycho-social characteristics of individuals are associated with responses to management incentives in a recreational fisheries context. The psycho-social characteristics considered in this chapter were (1) expectation of behaviour of others, (2) social norms, (3) ecological values, (4) personality types, and (5) risk preferences. While there is literature reviewing and testing some of the characteristics mentioned relating to compliance behaviours in fishing and non-fishing contexts, there is a gap in the literature exploring these characteristics concurrently within a controlled experimental setting. The implication of such a study will contribute to the gap in identifying the patterns in those who are consistently compliant, those who free-ride, and those who are influenced as intended by improving compliant behaviour for different incentives.

Chapter 5 examines fishers' management preferences towards different management tools in a highly consumptive recreational fishery. Specifically, this chapter uses a combination of a discrete choice experiment and an opinion-based survey to explore the potential heterogeneity in management preferences in the Tasmanian recreational Rock Lobster fishery, Australia. Although the fishery has extensive management in place, further restrictions are required to limit the amount of lobster caught for the recreational sector due to declining stocks. As a diverse fishery, with various fishing methods and a range of avidity levels, it is expected that the effects of management changes vary across different fisher groups as well as the type of restrictions imposed. A phone survey was used to ask fishers' opinions on how effective different management tools are at restricting catch and if they supported or opposed the tool. Additionally, a discrete choice experiment was used to assess if fishers' utility is associated with a management tool and to what extent fishers are willing to trade a change in one management tool for a change in another.

The final chapter concludes this thesis and offers opportunities for future research.

This thesis is presented in the style of thesis by publication. Each of the thesis core chapters are prepared in the style of journal articles which have been published, submitted or intended to submit for review to academic journals. The nature of this style of thesis, however, can generate some repetition of contextual information within the chapters, although this has been kept to a minimum.

Chapter 2 - When push comes to shove in recreational fishing compliance, think 'nudge'

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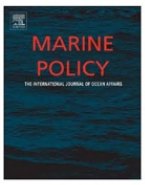

When push comes to shove in recreational fishing compliance, think 'nudge'

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Chapter 2

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2.1 Introduction

Fishing is a popular recreational activity in many places around the world (Smallwood & Beckley 2012). The global estimation of recreational fishing[1] participation is around 11% of people (Arlinghaus et al. 2015) with an estimated number of fishers ranging between 220 million (FAO 2012) and 700 million (Cooke & Cowx 2004). Recreational fishing provides participants with a number of social, economic and health benefits (Cooke & Schramm 2007; Ihde et al. 2011) as well as a potential source of protein (Cooke & Cowx 2006; Cooke et al. 2018). In some cases it also generates significant social and economic benefits to communities, for example through the flow-on economic and employment benefits arising from fisher expenditure and tourism (Cisneros-Montemayor & Sumaila 2010). Many recreational fisheries are managed under regulated open access regimes (Homans & Wilen 1997), which fail to fully curtail the destructive race behaviours characteristic of users of a common pool resource, which can result in excessive fishing capacity and user congestion, and overuse of fish stocks. Recreational fisheries are, therefore, prone to over-exploitation and with the most valued commercial species often targeted (Coleman et al. 2004), recreational fisheries have been credited with contributing to global fisheries declines (Worm et al. 2009; Cooke & Cowx 2004).

Global recreational fisheries are generally understudied, poorly understood (Young et al. 2014), and their scale and impact are largely underestimated (Cooke & Cowx 2006; Lewin et al. 2006; Pauly & Zeller 2016). For example, in Australia, recreational harvest is substantial and exceeds the commercial catch for a number of species, including Yellowtail Kingfish (Lowry et al. 2016), Blue Swimmer Crab and Snapper (McPhee et al. 2002). More widely, monitoring, surveillance and enforcement efforts by management are well below those for commercial fisheries (Haggarty et al. 2016). This is often due to capacity shortfalls in staff and financial resources (Gill et al. 2017) and consequently, very few comprehensive records of catch and effort exist (Cabanellas-Reboredo et al. 2017). The impacts of recreational fishing can affect size structure, stock abundance and evolutionary trajectories (Lewin et al. 2006), and will be further heightened by technological improvements (McPhee et al. 2002). However, poor knowledge and understanding of these impacts challenges the effectiveness of sustainable management (Arias 2015; Arias et al. 2016). To date, initiatives to limit and control recreational fishing activity have focused on addressing symptoms and not on the underlying causes of problems because of this lack of understanding (Cooke & Cowx 2004).

[1] Recreational fishing is often defined as any recreational activity that removes aquatic organisms, including but not limited to line fishing, spearfishing, netting and collecting (Smallwood & Beckley 2012).

The overall approach to recreational fisheries management has tended to mirror that of the commercial fisheries with a heavy emphasis on the use of regulatory tools, such as effort regulation and catch limits (Cooke & Cowx 2006). Ensuring compliance with such regulations is therefore a key element in effective fisheries management. Non-compliance with regulations in the global conservation context remains one of the largest illegal activities in the world, resulting in degradation to societies, economies and the environment (Haken 2011; Arias 2015). The threats that non-compliance poses on marine conservation and marine socio-ecological systems are also consequential; non-compliance has the potential to undermine management (Sullivan 2004) and sustainability (Keane et al. 2008), and to create conflict between user groups (Cooke & Cowx 2006; Kearney 2001). Conversely, ensuring recreational fishers' compliance with rules and regulations is particularly difficult due to factors such as the high number of participants and costs of enforcement, the absence of regular monitoring of recreational fishing activity, and the inherent difficulties in accurately determining catches. While management of both sectors tends to emphasise instrumental factors like economic incentives and deterrence for ensuring compliance (King & Sutinen 2010; Nielsen & Mathiesen 2003), the absence of formal management infrastructure in recreational fisheries (i.e. landing obligations, log books, electronic monitoring or on-board observers) renders this approach less effective and suggests the need for an alternative approach.

Although recreational and commercial fisheries share a number of characteristics, and enforcement and management tend to be similar, the two are fundamentally different (Cowx 2002). In particular, while commercial and recreational fishers both positively respond to catch rates, recreational fishers are generally more motivated by non-catch incentives (Arlinghaus 2006a). Non-catch motivations can be broadly categorised into three groups; mastery motivations such as mental stimulation (Beard, Jacob & Ragheb, Mounir 1980), achievement (Kuehn et al. 2013; Hunt & Ditton 2001) and trophy winning (Sutton 2003); social factors (Magee et al. 2018; Dillard & Bates 2011), and escapism (White 2008; Henry & Lyle 2003). Since the main drivers for recreational fishing behaviour extend beyond the key economic drivers of commercial fishing, the instruments needed for effective management of recreational fishing are likely to differ from those used in commercial fisheries. Despite this, such instruments have typically dominated recreational fisheries (Cooke et al. 2013). Moreover, the need to incorporate human dimensions for compliance management in recreational fisheries is increasingly being recognised and advocated for (Bergseth 2017; Arlinghaus et al. 2016; Hunt et al. 2013) and the use of voluntary and informal institutions for recreational fisheries management have been suggested (Cooke et al. 2013). However, the application of behaviourally-based approaches for compliance management has yet to be explored.

The overall aim of this chapter is to highlight how behavioural nudges may fill a critical gap in current fisheries management and improve recreational fishing compliance outcomes. The potential for lesser used, non-traditional approaches is highlighted through a narrative review of the peer reviewed literature on behavioural theory, specifically nudge theory. Nudge theory argues that through positive reinforcement or indirect suggestion, non-forced compliance can be achieved. The chapter aim is achieved with specific reference to the case of Australian recreational fisheries, which have particularly high participation and a fisheries regulatory regime typical of developed countries. Additionally, there is a considerable wealth of literature on recreational fisheries in Australia, specifically with a focus on compliance. A brief background of relevant compliance theory is provided along with the definition of nudge theory (Section 2), followed by a review of the compliance issues and current management within Australian case literature (Section 3). This provides the context for discussing which behavioural nudges may be effective in influencing compliance behaviour, with examples provided (Section 4). The chapter concludes by identifying a series of challenges and design considerations which will influence the effectiveness of nudges within recreational fisheries in Australia and elsewhere (Section 5).

2.2 Compliance theory in recreational fisheries

2.2.1 Traditional compliance theory

Compliance is defined for this chapter as adhering to the rules and regulations by recreational fishers. Compliance can be interpreted as either binary, i.e. no compliance vs. compliance, or as a spectrum, i.e. 'high', 'medium', 'low' (Arias 2015). The latter interpretation is more pertinent when considering compliance management as it is consistent with the notion that compliance is malleable and that gradual behavioural change can transition compliance along a gradient, rather than requiring behaviour to move from one opposite disposition to another. Non-compliance can be accidental or deliberate and can occur on a range of scales and frequencies, for example catching an undersized fish after a recent amendment to size restrictions, or a conscious, organised effort to catch a high value species with the intention to profit from sales. Compliance can be viewed as a function of deterrence and voluntary compliance. Deterrence is the outcome of deliberately implemented prevention tactics including the likelihood of getting caught and the severity of the repercussions. Voluntary compliance, on the other hand, occurs when people willingly choose to adhere to the rules and regulations regardless of the expected repercussions of non-compliance (Putt & Nelson 2008).

Identifying the determinants of compliance and knowing what drives compliance behaviour is complex, and this is reflected in the evolution of compliance theories and models. Becker (1968) was the first

to model the broad components of compliance and to discuss how to choose enforcement levels. Based on the assumption of rational economic behaviour, this model assumes that the decision to infringe is based on the expected return to breaking the rules, taking into account the direct returns and costs of different compliance behaviours, and the risk of detection and punishment. Some fisheries compliance models have built on Becker's model to include some of the complexity, incorporating additional parameters including individual effort (Anderson & Lee 1986) and personality types (Chavez & Salgado 2005). However, they are still better equipped for explaining compliance behavior where economic drivers dominate (i.e. commercial fisheries) and inadequately capture the full complexity of the problem (Nøstbakken 2008).

The recognition that compliance behaviour is not solely based on economic gains is expanding and is reflected in compliance models relaxing the assumption of pure instrumental rationality of agents and acknowledging the importance of normative behavioural drivers. Expansion of fisheries compliance models used concepts from psychology and sociology to extend the rational choice model to also include intrinsic values such as personal morality, social reputation and legitimacy (Kuperan & Sutinen 1998; Sutinen & Kuperan 1999). Intrinsic values and informal management have been integrated within theoretical models of commercial fisheries (Hatcher et al. 2000; MacKenzie & Cox 2013; Nielsen & Mathiesen 2003; Nøstbakken 2013; Xepapadeas 2005). However, only recently have compliance models been tested on recreational fishing compliance behaviour (Thomas et al. 2016). The integration of normative drivers results in better prediction of compliance behaviour, with psycho-social factors such as social norms, being the most significant driver compared to instrumental drivers (Thomas et al. 2016). Therefore, the predictors of compliance are broader than the earlier deterrence models assumed, and the instrumental factors, upon which recreational compliance management is largely based, might not be adequate. Understanding of normative drivers is yet to be adequately applied in management, as harnessing social norms, legitimacy and personal morality into action is challenging. However, this is a gap that nudges, as successfully trialled and tested tools in influencing behaviour in other domains, may fill.

2.2.2 Nudge theory

If deterrence relies on shoving people to make certain decisions (such as complying with rules), a nudge can be thought of as a subtler way to encourage a decision that is in people's best interest. For example, while it is rationally in people's best interest to save for retirement, and most countries offer tax incentives to do so, people frequently still do not save enough for retirement (Madrian & Shea 2001). A nudge to overcome this is to apply an auto-enrolment into saving schemes, to make this decision more salient and increase average saving rates (i.e. up to 13.6% (Thaler & Benartzi 2004).

The term 'nudge' was first coined by Thaler & Sunstein in their book *Nudge: Improving Decisions about Health, Wealth and Happiness* (2008) with a nudge defined broadly as a change to "any aspect of choice architecture that alters people's behaviour in a predictable way without forbidding any options or significantly changing their economic incentives" (2008;6). Choice architecture refers here to the way in which options are presented to people that in turn may influence their choice. There have been a number of iterations of the definition of a nudge since Thaler and Sunstein (Hausman & Welch 2010; Hansen & Jespersen 2013; Mongin & Mikaël Cozic 2017; Thaler & Sunstein 2008). The most encompassing definition is provided by Hansen (2016, 16) who states that a nudge is "a function of any attempt at influencing people's judgment, choice or behaviour in a predictable way (1) that is made possible because of cognitive boundaries, biases, routines and habits in individual and social decision-making posing barriers for people to perform rationally in their own declared self-interests and which (2) works by making use of those boundaries, biases, routines, and habits as integral parts of such attempts". The theory that underpins the ability of nudges to produce such changes is, therefore, primarily based upon insights from behavioural economics and encompasses ideas from both psychology and sociology (John et al. 2011; Whitehead et al. 2014). Nudges rely on understanding and being able to predict how and why human behaviour deviates from that predicted by standard economic theory. Nudges are designed interventions that target the behavioural biases that arise from the three acknowledged bounds of human behaviour[2] (Mullainathan & Thaler 2015).

Nudging, therefore, is about changing the choice environment to make certain options more salient, broadly through indirect suggestion or positive reinforcement. Equally important to understanding what a nudge is, is to understand what is not a nudge. Hansen (2016;16) clarifies that "a nudge amongst other things works independently of: "(i) forbidding or adding any rational relevant choice options, (ii) changing incentives, whether regarded in terms of time, trouble, social sanctions, economic and so forth, or (iii) the provision of information or rational argumentation". For instance, in the context of compliance with a shorter catch season for the female of a species, according to the definition above the following would not be considered a nudge: (i) forbidding the catch of female all year round, which would forbid the choice option; (ii) incorporating a tagging system for females that is allocated through an application based lottery process, which would change incentives by increasing the effort required; (iii) providing factual information on the ecological importance of not catching females during spawning season.

[2] There are three acknowledged bounds which are; *bounded rationality,* which reflects the limited cognitive abilities that constrain human problem solving; *bounded willpower,* captures the fact that people sometimes make choices that are not in their long-run interest and *bounded self-interest,* incorporates the fact that humans are often willing to sacrifice their own interests to help others (Mullainathan & Thaler 2015).

2.3 Current management and compliance issues: an Australian perspective

2.3.1 Current regulatory management

The importance of recreational fisheries in Australia is recognised economically, culturally, and ecologically (Brooks et al. 2015). Recreational fishing participation in Australia is high, with about 3.5 million people (14% of the population) fishing at least once each year (Fisheries Research and Development Corporation 2016). Due to factors such as the extensive Australian coastline, the absence of regular monitoring of recreational fishers, and the high costs of enforcement, ensuring compliance with rules and regulations is challenging. Compliance in recreational fisheries has been of high interest in Australia, with numerous academic efforts made to better understand such a tenacious problem (Bergseth et al. 2017; Bergseth & Roscher 2018; Arias & Sutton 2013; Smallwood & Beckley 2012), as well as governmental and managerial efforts to improve compliance (Green & McKinlay 2009; NFCC 2015; Putt & Nelson 2007). Sub-culture theory would suggest that groups, such as recreational fishers, share norms and values (Bergseth & Roscher 2018; Fischer 1995). This, combined with the high participation rates and cultural importance recreational fishing has in Australia (Henry & Lyle 2003), makes it a good case for exploring the potential of behavioural nudges for enhancing compliance.

Within the Australian fishing zone it is the State and Territory governments that assume responsibility for recreational fishing (AFMA 2013), with a few larger pelagic species being the exception, such as Bluefin Tuna and certain shark species managed under Commonwealth and international jurisdiction (Tracey et al. 2013). Recreational fisheries in Australia are managed via a mixture of regulations and rules that either aim to control fishers' input or their output (Morison 2004). Input management aims to control *who* is allowed to fish, *where* they are allowed to fish, *when* they are allowed to fish and *how* they are allowed to fish. This includes any type of access controls such as licenses and fishing rights, as well as spatial controls such as protected areas. Output controls on the other hand address *what* and *how much* people are allowed to catch. This includes both quantitative and qualitative restrictions. Total allowable catch and bag limits are quantitative restrictions on the mass or numbers of fish harvested, whereas, qualitative output controls are restrictions on sex, species or size limits.

There are several consistencies and differences in management delivered across all state jurisdictions. There are uniform regulations on the removal of threatened species and every coastal jurisdiction has size, bag and possession limits for certain species with some also having boat limits. However, the specific details differ e.g. the size limit for Bream in Tasmania is 25cm, but it is 30cm in South Australia. For reasons such as protecting spawning stocks during reproductive periods, there are temporal closed seasons in every jurisdiction, except the Northern Territory. There are some differences in the

requirements for recreational fishing licenses across Australia. For example, while recreational fishers in New South Wales and Victoria require licenses for any fishing activity, in the Northern Territory, South Australia and Queensland they do not require general or specific gear or species licenses for recreational fishing activities. Within Western Australia and Tasmania, fishers do not require general recreational fisheries licenses but there are gear and species-specific licenses (for species such as Western and Southern Rock Lobster, respectively).

Through monitoring and enforcement of these regulations, punishments for non-compliance include issuing fines, loss of fishing licenses and for extreme cases, imprisonment. Empirical research on compliance in green zones within the Great Barrier Reef in Australia found that the fear of being fined is ranked as the highest compliance driver for not fishing within marine reserves (Arias & Sutton 2013), however the perception of higher catches in reserves and a low probability of detection are ranked as the primary motivations of non-compliant behaviour within these reserves (Bergseth et al. 2017). In a New Zealand recreational fishery, instrumental factors, such as probability of detection and probability of conviction, were found not to be significant drivers of compliance behavior (Thomas et al. 2016), and generally compliance management solely based on economic incentives targeting deterrence has been questioned (Arlinghaus et al. 2002). Accordingly management is being advised to emphasise and encourage voluntary compliance behaviour (Arias & Sutton 2013; Arias 2015; Bergseth & Roscher 2018).

2.3.2 Compliance Issues

The review of compliance issues is delivered as a narrative review that considers academic, policy and grey literature to provide context for the subsequent discussion of behavioural incentives. This literature review highlighted some pertinent compliance issues within recreational fisheries in Australia, including but not limited to the ten compliance issues found in Table 2.1. Of these compliance issues, five represent violations of input controls with examples of issues violating each of the four types of input control (i.e. *who, where, when* and *how*). Fishing without a licence, for example, violates management controls that prescribe *who* is permitted to fish, and fishing with restricted gear is non-compliance with *how* to fish. The remaining five issues represent violations of output controls, with *what* was being caught comprising the majority of the compliance issues, including retaining juvenile fish, ignoring biotoxin or consumption warnings, illegal selling of catch and fishing for protected species. The other output control that was violated was regarding *how much* is being caught i.e. exceeding catch limits. Several the compliance issues raised within this review relate to violations of output controls, relating to *what* and *how much* is being caught, suggesting these controls may require additional management tools for compliance. Table 2.1 also provides specific examples of each

of the compliance issues, a description of the current legislation and maximum financial punishment, the type of monitoring and, if suggested in the literature, an alternative, non-fiscal management alternative. Currently most compliance issues are managed through deterrence-based legislation requiring some sort of monitoring, with few examples of informal enforcement or compliance measures targeting voluntary compliance.

The financial repercussions for fishers who do not comply with regulations ranged from a $50 on the spot fine, to as much as $400,000 for trafficking a commercial quantity of a priority fish species (Western Australian Department of Fisheries 2010). A national study of crime in the Australian fishing industry stated that stakeholders believe legislation had inadequate penalty provisions and there was doubt in the prosecution and sentencing (Putt & Nelson 2008). This is reflective of generally low conviction rates globally for recreational fisheries with a noted rarity of prosecution of fisheries crime and leniency when it does occur (Minter 2008). Overall perceived low conviction rates may reflect the fact that in jurisdictions other than Victoria and New South Wales, numbers of convictions and fines are not publicised, for example through fisheries department websites (Victoria State Government 2016; NSW Department of Fisheries 2016). Other forms of information sharing is used, for example through press releases on successful convictions and increases in monitoring within the Great Barrier Reef, in New South Wales (GBRMPA 2018), and fisheries departments sharing convictions on non-compliance on Facebook, which will reinforce the norm and perception of enforcement (Tasmanian Fisheries 2017).

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Table 2.1 Common compliance issues within Australian recreational fisheries and associated legislation, financial punishment, and monitoring, and if noted any non-fiscal incentives for combating non-compliance.

Management method		Compliance issue	Example	Current legislation	Financial Punishment	Type of monitoring	Non-fiscal incentives	Literature cited
Input	*Who*	Fishing without a license	Fisherman fined after being caught without licence in New South Wales (NSW Department of Fisheries 2008)	Fisheries Management Act 1994 of New South Wales	$200 on the spot fine and upwards of $210-2500	Fisheries officers	Voluntary code of conduct	Lloret et al. 2008 Greiner et al. 2000; NSW Department of Fisheries 2008
	Where	Fishing within protected areas	Fishing within green zones in the Great Barrier Reef Marine Protected Area, and the Ningaloo Marine Park (Bergseth et al. 2015; (Smallwood & Beckley 2012)	The Environment Protection and Biodiversity Conservation Act 1999	fines, confiscation of property court hearing warnings and jail	Aerial & vessel-based surveillance, indirect observations, reports & on-site observations	Increased involvement of fishers in planning	Bergseth et al. 2015;McCook et al. 2010; Smallwood & Beckley 2012; Read et al. 2011; Sethi & Hilborn 2008
		Not complying with territory rules resulting in conflicts / interfering with others gear	Conflict between recreational and commercial fishers in New South Wales/Western Australian (Beattie 2016)	Fisheries Act 2010 Commercial fisher gets priority	Maximum penalty $50 Boat seized	Self-reporting	N/A	Beattie 2016;Kearney 2002
	When	Fishing within closed season	Western Australian fishermen fishing within closed seasons (WA News 2009)	Fisheries management (General) regulation 2007	First offence—$10 000; for a second or subsequent offence—$20 000.	Aerial Surveys	Rights based fishing	Kearney 2001; Smallwood & Beckley 2012
	How	Not complying with gear restrictions resulting in boat impacts on environment	Damage to seagrass beds/ reefs from unsuitable gear in Victoria (Kearney 2002)	Fisheries Act 1995 of Victoria. The Great Barrier Reef Marine Park Act 1975	$2,000-$10,000 in Great Barrier Reef Marine Park Authority	Community reporting of ecological data	Codes of conducts and restricted access penalties not just monetary	Kearney 2002; *Great Barrier Reef Marine Park Amendment Bill 2001*
Output	*What*	Illegal selling of catch	Failing to clip the tail rock lobster to sell on (Putt & Nelson 2007)	Fisheries management (General) regulation 2007	Max penalty $5,000	Marine police	Community reporting	Kearney 2002;Putt & Nelson 2007
		Fishing for protected species	Queensland shark finning (Shiffman et al. 2014)	Fish resources management Act 1994	$1000-$5000	On site landing checks	Using length instead of mass in trophy fishing	Shiffman et al. 2014
		Individuals ignoring biotoxin/consumption warnings/ advisories	Fishing and eating during biotoxin closures in Tasmania (Tasmanian Government 2016)	Informal / advisory	N/A	N/A	Co-management assisting with risk assessment and risk management	Burger 2000; Tasmanian Government 2016
		Retention of juvenile fish	Keeping juvenile finfish in South Western Australia (ABC 2012)	Fish Resources Management Act 1994 of Western Australia	$2,000	Fisheries officers	Expansion of volunteer programs	McPhee et al. 2002; Kearney 2002; Blyth et al. 2002; ABC 2012
	How much	Exceeding catch limits	Queensland fisherman caught 50 times the limit (Hall 2016) ; Western Australian fishers caught 405 abalone over limit (Beattie 2016)	Fisheries Act 1994 of Queensland. Fish Resources Management Act 1994 of Western Australia	$4,000 Penalties up to $400,000	Queensland Boating and Fisheries Patrol (QBFP) district officer Fisheries officers	Shame file in Queensland paper	Beattie 2016; Hall 2016; Wilberg 2009; Western Australian Department of Fisheries 2010

In addition to the laws and regulations in place to manage the non-compliance issues, there were also non-fiscal incentive-based ways of addressing compliance that touch on behavioural understanding (Table 2.1). These include co-management, and increased participation in, and expansion of, volunteer programs. These types of initiatives build upon trust and legitimacy of user groups, which have been shown to encourage compliance (Karper & Lopes 2014; MacKenzie & Cox 2013). Every State has an illegal fishing hotline for members of the public to report any illegal fishing activity they witness such as Fishwatch in Tasmania and New South Wales or 13FISH in Victoria. There is no punishment for not reporting any illegal activity through the hotline and generally there is no financial incentive to do so. The presence of self-monitoring by peers is a benefit to any compliance management as it increases monitoring capability and reinforces social acceptability of behaviours. The Great Barrier Marine Park Authority are disseminating a number of press releases on compliance convictions, emphasizing the punishments and unacceptance associated with poaching within the marine reserve (GBRMPA 2018). Another example of reinforcing social acceptability is through a shame file (*Hook, line and stinkers)* produced with government input, such as that published in a Queensland paper that listed cautionary tales of non-compliant convictions (without naming the culprits) along with reminders of the rules and regulations and illegal fishing hotline (Hall 2016). Although there is no empirical evidence to suggest this specific example is effective in changing behaviour, a field experiment tested the influence of shame on voter attendance in the US and found that people complied with voting norms when non-voters were named in a local newspaper and the risk of shame was present (Panagopoulos 2010). Thus, using a shame file in a local newspaper may be an effective addition to laws and regulations for regulation compliance.

There is generally little information available on actual compliance rates. The crude rate of non-compliance - which is calculated by looking at the number of offences that are weighted by severity over the total number of contacts made by fisheries officers - in Western Australia remained around six offences per every 100 checks from 2000-2007 (Green & McKinlay 2009). More recently, as many as 18% of surveyed fishers admitted to poaching in the last year within the Great Barrier Reef Marine Park (Bergseth et al. 2017). It has been said that the number of observed offences will be a function of enforcement effort as a fraction of the total number of offences committed (Green & McKinlay 2009), with a suggested hypothetical relationship between enforcement effort and offences. While this estimation is useful as it offers an opportunity to derive a rough calculation for compliance rates it neglects the offences that are prevented through efforts other than deterrence. For example, the compliance issues associated with territory conflicts are predominantly self-monitored, and non-compliance with consumption warnings for biotoxins are also self-monitored (Table 2.1). While coercive measures such as fines and prosecution are appropriate for recidivists or serious offenders,

persuasion and warning based compliance strategies can be used to influence accidental non-compliers (Arias 2015). Managers may overlook self-regulation and voluntary compliance as compliance tools since there is no direct measure of their impact on convictions.

2.4 Potential nudges in recreational fisheries

As demonstrated through the discussion of Australian compliance issues, even when punitive methods are in place non-compliant behaviours can persist and additional management levers may need to be deployed. Nudges may be a potential, innovative tool to bolster traditional management by encouraging voluntary compliance by making certain decisions more salient. The use of nudges in public policy has increased over the past decade (Benartzi et al. 2017), including examples in energy conservation and energy efficiency investments, transport choices, water conservation and sustainable food consumption (OECD 2017a; OECD 2017b). Examples specifically targeting compliance behaviour can be found in taxation (Cadsby et al. 2006; Li et al. 2011) and environmental regulation (Behavioural Insights Team 2015). While the use of nudges in marine management has been advocated for (Cvitanovic et al. 2018) there is little evidence of their application in addressing compliance issues in recreational fisheries management. A commonly used typology of nudges comprises four different types; i) simplification and framing of information, ii) changes to physical environment, iii) changes to the default policy and iv) use of social norms and comparisons (Mont et al. 2014; Lehner et al. 2016). This typology is used along with the extant literature on applied nudges in other sectors to identify a series of potential nudges that can be tailored to the recreational fishing compliance problem. Table 2.2 and the following sections describe these examples, linking each to the typology, the compliance issues and associated management control method it is intended to address.

Table 2.2 Potential nudges for addressing compliance issues in recreational fishing.

Management method		**Compliance Issue**	**Behavioural Nudge**	**Potential recreational fishing application**
Input controls	*Who*	Fishing without a license	Social norms / simplification and framing of information	Wording of licenses/ statistics e.g. 23% of people were checked by marine police last year/ 90% of people display their license ID number on their potting floats
			Defaults	Automatic renewal for licenses
	Where	Fishing within a protected area	Defaults	'Opting-in' to voluntary closures with the option to opt out
	When	Fishing in a closed-season	Use of social norms and comparisons	Regulation reminders including comparisons to previous year's fishers' opinions/ compliance rates
	How	Not complying with gear restriction/ gear impacts on environment	Defaults	Default subscription to conservation efforts as extra payment of license
Output controls	*What*	Illegal selling of catch	Changes to physical environment	Eyes on boards at boat ramps
		Retaining juveniles/ undersized fish	Simplification and faming of information/ Changes to physical environment	Rephrase regulation reminders on apps from juvenile to baby fish/ little ones. Persuasive messaging on measuring rulers. Spray paint size limits at popular spots (Fig. 1)
	How much	Exceeding a catch limit	Simplification and framing of information	Persuasive messaging and anchoring catch limit below legislated limit

2.4.1 Simplification and framing of information

Framing is already being used in recreational fisheries management to encourage compliance, for example, persuasive messaging can be seen on the ruler distributed by the Inland Fisheries Service that can be used to measure Tasmanian trout (Fig. 1a). At the legal minimum size limit the message "It may be to size but do you really want it" appears then along the ruler at increasing measurements it states; "Not bad!" "Impressive!", "Worth bragging about!" then "Officially a monster!" (Fig. 1a). This type of messaging is intended to encourage fishers to aim higher than the minimum size by removing the size limit as the anchor and reduce the likelihood of fishers keeping anything below the size limit. Reframing information can also involve the use of descriptive words alongside informative words, for example "Grandma's Zucchini cookies" instead of "Zucchini cookies" increased sales by 27% (Lehner et al. 2016). A comparable nudge is already being applied in Tasmania's FishCare key messages, stating "Put the little ones back gently" to encourage fishers not to retain juvenile or undersized fish (Fig. 1b).

Another nudge in fisheries management in Australia has been applied through the framing of the catch limit in a cattle and camping station in Western Australia. It states; "Ideally we would like visitors to

take no more than 2 fish per day to ensure the sustainability of this wonderful resource. We have a possession limit of 5kg. Catch a fresh fish each day, no need to freeze, there is no comparison to the taste" (Warroora Station, 2016). By first introducing a lower bag limit than the limit of 5 as set by the Western Australia State regulation (for the Gascoyne coast), people tend to use that as an anchor or reference point, and they will be primed[3] to act according to this. The message is also framed based on personal gain from catching fresh fish and using descriptive words (i.e. protect the 'wonderful' resource), rather than framing non-compliance as a punishable offence. Framing has also been used as a nudge in healthcare, where patients were more likely to commit to having surgery when they were told '90% of people survived after five years' versus being told that 'after five years 10% did not survive' (McNeil et al. 1982). A similar nudge in recreational fisheries could be applied in reporting enforcement statistics, for example, '23% of people were checked by marine police last year' rather than '73% of people were not checked by marine police last year'.

Figure 2.1 Examples of nudges used in Tasmanian recreational fishing and inland fisheries; a) an example of persuasive messaging regarding the minimum size of trout (text in red under the measurements); b) an example of simplification and framing nudge as part of the FishCare core messages to not retain juvenile or undersized fish; c) an example of changes to the physical environment nudge with a spray-painted reminder to measure catch that is the same size as the minimum legal size of the commonly caught flathead.

[3] Priming, here, refers to the cues that can unconsciously drive behaviour (Friis et al. 2017), for example, how background music will subconsciously influence wine choices (North et al. 1999) and description of taste (North 2012).

2.4.2 Changes to physical environment

Changes to the physical environment can act as a reminder or can deliver a message regarding social acceptability. An example is currently being used to reiterate the size limits of a popular recreational fish in Tasmania where the government has spray-painted a stylised picture of a Sand Flathead, along with the message "Measure your catch" (Fig. 1c) in certain locations. Changes to the physical environment like this have successfully reduced littering with green footprints painted on the ground leading to bins (Ly et al. 2013), and stickers near taps have assisted in water conservation (Datta et al. 2015). Recent evidence has shown that people tend to act pro-socially when there is an image of eyes watching them. The influence of 'being watched' on people's motivations is twofold, a positive motivation to gain future reward by doing the right thing and a negative emotion to avoid violating an established norm (Oda et al. 2015). The presence of eyes creates subtle cues of being watched and feeling seen, and it makes people act more honestly and pro-socially, as well as inducing a public awareness (Pfattheicher & Keller 2015). This nudge could be applied in recreational fisheries by displaying some similar watching-eye installations at popular boat ramps along with messages about illegal selling of catch, fishing for protected species, or fishing without a license. Additionally, the message along with a picture of eyes or someone looking through binoculars could be framed around encouraging fishers to report any non-compliance to further encourage self-monitoring on top of the cue to act more pro-socially.

2.4.3 Changes to the default policy

One of the most successful types of nudge is to change the default option. This builds from the understanding that many people dislike engaging in actively making a choice but instead will stick with the default (Beshears et al. 2008). Given this, if the default option is pro-environmental (or the type of behaviour managers want to encourage) it can have a large cumulative positive effect (Schubert 2017). Large scale initiatives have been applied through default green energy policies. For example, in Germany 16% of energy providers automatically include their clients in green energy (Sunstein & Reisch 2016) by presenting this as the default option. There are a few examples of default nudges being applied in different Australian fisheries departments, but not yet targeting compliance. For example, defaults are being used in Tasmanian fishing licenses, opting in for digital licenses (DPIPWE 2017), which will reduce costs for printing and posting, thus making more resources available for other purposes. To address compliance issues, an automatic license renewal could be established in recreational fisheries management to reduce the number of cases of non-deliberate fishing without a license. Incorporating default options in license renewals could include agreements to comply with voluntary closures or no-go areas but with the possibility to opt out if they desired. There could also

be additional fees included in the default to contribute to conservation initiatives to abate the impacts from boat or gear damage that has an opt-out option.

2.4.4 Use of social norms and comparisons

As social beings, individuals are influenced by the actions of other's (social norms) and behaviours can be impacted through comparisons to peers (social comparisons). Within environmental management, in water and energy conservation, the practice of normative messaging has become an effective way to apply nudges (Ferraro & Price 2011; Allcott 2009). For example, descriptive social norm-based messaging for water management was found to have an effect on a short and long term basis (Bernedo et al. 2014). Experimentally social descriptive norms have also been found to increase cooperation between unknown subjects in common pool resource use when theoretically they should have behaved selfishly (Biel & Thøgersen 2007). This suggests people's self-interest is bounded, because they are willing to sacrifice their own gains to help others (Mullainathan & Thaler 2015).

Social norms have been shown to be particularly powerful in explaining recreational fishing compliance behaviour (Thomas et al. 2015) and is therefore likely an effective nudge. The presence of social norms on compliance behaviour can be observed through social media. For example, currently when a conviction of non-compliance occurs it will be widely circulated by some Australian Fisheries departments on Facebook. The response to these Facebook postings often includes a disapproving discourse. A post regarding a conviction for retaining undersized fish received comments such as; "Should be a more hefty fine and lose gear" and "Name and shame" by other members of the group (Tasmanian Fisheries 2017). This experience can be used by fisheries departments as feedback to the wider community of the social norm regarding recreational non-compliance.

The strength of a social norm nudge can be increased with an injunctive norm, which includes a consciousness of what is accepted or opposed by others (Reno et al. 1993). Potential nudges that incorporate social norms and consciousness to elicit compliance in recreational fisheries could resemble feedback of previous fishers' decisions in response to a regulation. For example, 'According to last year's data the average fisher was happy to catch less than the bag limit'. This statement gives consciousness of the decision as well as reference to the norm. A nudge based on social norms can also be complemented by simplification and framing strategies (discussed above). For example, in Western Australia people are required to display their potting ID license. Reporting by the Western Australia government could apply a descriptive norm to encourage compliance by stating '90% of people display their license ID number on their potting floats' rather than "10% of people don't display their license ID number on their potting floats" to elicit a change in behaviour.

2.5 Challenges and design considerations for nudges in recreational fisheries

Nudges vary in approach, application, and according to the type of choice that is being influenced, targeting either subconscious or conscious efforts (although most examples focus on the subconscious (John et al. 2011; Moseley & Stoker 2013; Whitehead et al. 2014)). The use of nudges in public policy has not been without its critics, with concerns voiced about whether they are ethical (Schubert 2014), manipulative (Conly 2013) or are a risk to human agency (Waldron 2014). For example, the use of a social norm nudge aiming to reduce unnecessary laundering of towels in a hotel that used false statistics of reuse of other guests drew criticism on ethical grounds (Goldstein et al. 2008). In defence of nudges as a legitimate instrument of public policy Sunstein (2017) reiterates that they must preserve free choice, and while nudges can change people's behaviour by providing information in a different way or making certain decisions easier, they must not be coercive. In the case of recreational fisheries, nudges may pose an additional risk to the legitimacy and transparency of management if they are based on false statistics or replace initiatives that require more resources like co-management and stakeholder engagement, which have been shown to encourage compliant behaviour in fisheries (Jentoft et al. 1998; Kaplan & McCay 2004; Nielsen 2003).

The effectiveness of nudges in creating the intended behavioural changes has also been questioned. For example, nudges that produce confusion, rather than simplifying choices, or nudges that result in reactive or 'boomerang' responses will be ineffective (Sunstein 2016). Within recreational fisheries, if fishers are not influenced by the actions of other's or want to defy other's expectations, they would not likely be influenced by a nudge using social norms and comparisons. For example, in a study on compliance behaviour within the Great Barrier Reef, 16-21% of the fishers surveyed reported that they did not care if others approved of them poaching. This attitude strengthened as social distance increased, i.e. fishers cared what friends and family thought, but not what fishers they did not know thought (Bergseth & Roscher 2018) This suggests that injunctive social norms around what other fishers think is acceptable may not influence the behaviour of this sub-set of fishers and a social norm nudge based on this may not be effective. Some people may simply be emboldened by the prospect of disapproval and flouting convention, while other individual's reflective judgements may not align with the norm and therefore not be influenced by it (Sunstein 1996).

Additionally, the longevity of the influence of a nudge may be inconsistent and a pattern of 'action and backsliding' has been identified in some applications (Allcott 2009). When attempting to change habits, as in the case of energy consumption, new behavioural patterns may be slow to become adopted (Michalek et al. 2015), therefore nudges should be applied on a regular basis to have a long term effect (Allcott & Rogers 2014). For recreational fisheries in which a one-time reminder of

regulations or rules may cease to be salient and become background noise, nudges may need to be regular and periodically altered to stay meaningful and illicit a reaction. Additionally, compliance behaviour itself is dynamic, meaning that any management tool needs to be adaptive to account for this.

The effectiveness of nudges may be weakened where they produce compensating behaviour (Sunstein 2016). The history of fisheries management is replete with examples of such unintended consequences (Abbott & Haynie 2012; Cinti et al. 2010), for example with attempts to control total fishing effort regularly undermined by the ingenuity of fishers in substituting between various forms of controlled and uncontrolled effort i.e. when restrictions on the number of vessels results in increased vessel or engine size. Unintended compensating behaviours can also be expected in a recreational fisheries context. For example, in a recreational fishery in which a nudge improves compliance with spatial closures but results in an increase in pressure outside the closed areas, with overall negative ecosystem outcomes. Failure to account for these effects may unintentionally decrease ecosystem health or overall compliance.

Poor or inaccurate understanding of the relevant choice environment can also contribute to ineffective nudges (Sunstein 2016). This reinforces the recent call for greater emphasis on better understanding of behavioural drivers of recreational fishers in complex socio-ecological systems (Bergseth 2017; Arlinghaus et al. 2016; Hunt et al. 2013). Nudge design will be further complicated in cases where there are large differences across individuals in personal characteristics and behavioural drivers. Costa & Kahn (2013) found evidence of varying effectiveness of an energy conservation nudge depending on political ideology and suggest that nudges need to be targeted to specific groups. The population of recreational fishers has been found to be highly heterogeneous in terms of socio-economic characteristics (Floyd et al. 2006), attitudes (Lyle & Tracey 2016), values (Frijlink & Lyle 2010), and motivations (Copeland et al. 2017), suggesting that a 'one nudge fits all' approach to improving compliance is unlikely to work effectively and that multiple or different nudges will be needed to account for these groupings.

The interaction between traditional deterrence and nudge interventions in recreational fishing is unclear. Nudges to encourage compliance need to be implemented in a way that encourages voluntary compliance without negating or undermining the effectiveness of deterrence. While economic incentives, on which deterrence is based, can motivate prosocial behaviour they can also weaken altruistic values (Lacetera 2016). For example, enforcement of gear restrictions has led to increased overfishing perhaps through crowding-out of the intrinsic motivations that underpin

voluntary compliance or by triggering extreme non-cooperative behaviour in response to those who break the rules (MacColl 2015). The implied feedback system between voluntary compliance and deterrence, means that it is possible that deterrence and nudge interventions are substitutes or complements. Understanding the nature of this interaction is critical to successful nudge design.

Effective nudge implementation in recreational fisheries requires a systematic and rigorous design process. To this end, Ly et al. (2013) suggest creating a 'decision map', outlining the critical actions involved with following through with a decision, such as whether to comply with a recreational fishing bag limit regulation or not. This involves considering broad properties of the decision (incentives and motivations), information sources, features of the individual's mindset and environmental/ social factors. From this decision map, factors that prevent individuals from following through with their intention can be identified. These factors, which can be thought of as 'bottlenecks', are the points at which potential nudges may result in efficient behaviour changes and where nudge efforts should be concentrated i.e. the biggest bottleneck will have the greatest potential for a nudge to have the most influence (Ly et al. 2013). Understanding possible behavioural influences, such as status quo or confirmation bias, and heuristics, like anchoring and social proof, involved in these bottlenecks informs the selection and design of a nudge.

To account for the complexities of the behaviour of common pool marine resource users and for the fact that recreational fisheries are often based on stocks that are shared with other user groups, it will be important that potential compliance nudges are tested in a systematic and controlled manner, for example through repeatable field and laboratory behavioural experiments. Within this context, difficulties in predicting the behavior of fishers and their reactions to other fishers' behaviour, the transient and occasional nature of recreational fishing, and the heterogeneity of fishers will need to be accounted for. Additionally, the ambiguous outcome of combining deterrence and nudge intervention will need to be acutely considered. The 'test, learn, adapt' approach (developed by the Behavioural Insights Team in UK and adopted by Australian Behavioural Insights Team) provides a useful model for progressing the use of recreational fishing compliance nudges, and is consistent with the adaptive management approach used in Australia and elsewhere. The iterative nature of this approach is essential when considering fisheries management, which must take account of a dynamic environmental, social, economic and political environment.

As highlighted above, targeting the complex cognitive biases that influence individual choice and behaviour to produce improved recreational fishing compliance outcomes through nudges is likely to be challenging. Nudges do not offer a quick fix to replace cases where traditional policy instruments

have failed. Rather there is the potential for behaviourally-based management to augment and complement existing deterrence regimes and, while suggesting a number of potential nudges for compliance in recreational fisheries, caution is advised. As with any new and novel management approach, nudges need to be rigorously tested to demonstrate their cost-effectiveness and to avoid unintended consequences.

2.6 Conclusion

Recreational fisheries management aims to promote both sustainable and high-quality recreational fishing activities. However, knowledge about compliance rates of recreational fishers is scant and concerns have been raised over the impact of potential breaches in recreational fishing compliance at all scales. The effectiveness of traditional punitive deterrence is limited, yet compliance management is heavily reliant on this enforcement and monitoring intensive compliance approach, which is costly and seem to be associated with poor conviction records. In this chapter, the potential of behavioural based management, specifically nudges, to complement traditional deterrence approaches to help improve compliance in recreational fisheries is explored. Within Australia there are only a few examples of behavioural based measures in recreational fisheries compliance management found. However, based on their theoretical foundations, nudges may present an inexpensive, and potentially highly effective opportunity for recreational fisheries management. Several potential nudges that could be used to complement current compliance management (based on framing, changing the physical environment, presenting default options, and social norms) are suggested, albeit with caution. The history of fisheries management is replete with examples of unintended consequences, and hasty implementation of under-tested and poorly designed nudges might not achieve the desired results. However, through careful design and when embedded within an adaptive management framework, nudges have the potential to contribute to improved recreational compliance thereby avoiding the threats that non-compliance poses to marine systems, locally and globally.

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Chapter 3 - The influence of nudges on compliance behaviour in recreational fisheries: A laboratory experiment

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The influence of nudges on compliance behaviour in recreational fisheries: a laboratory experiment

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Author	Contribution	%	Signature
MM	Conceived, developed and designed the study; led data collection activities; contributed data analysis; wrote the manuscript	70	
SY	Contributed to the design and data collection activities; led data analysis; provided input into the writing of the manuscript	12	
SJ	Contributed to the development of the study; provided input into the writing of the manuscript	5	
HS	Contributed to the design and development of the study; provided comment on draft versions of the manuscript	5	
IvP	Contributed to the development of the study; provided comment on draft versions of the manuscript	4	
TE	Contributed to the development of the study; provided input into the writing of the manuscript	4	

Chapter 4 - Individual psycho-social characteristics are associated with compliance responses to management incentives in a recreational fishery experiment

Chapter 4

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Individual psycho-social characteristics are associated with compliance responses to management incentives in a recreational fishery experiment

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SJ	Contributed to the development of the study; provided input into the writing of the manuscript	7.5	
SY	Contributed to the design and development of the study; provided comment on draft versions of the manuscript	7.5	
HS	Contributed to the development of the study; provided comment on draft versions of the manuscript	3	

4.1. Introduction

Recreational fisheries are generally managed as a regulated open access resource, but the common pool nature of recreational fisheries makes them vulnerable to overexploitation. Due to the high numbers and wide distribution of fishers, however, enforcement of rules and regulations for recreational fishing is costly and typically low (King & Sutinen 2010; Nielsen & Mathiesen 2003). Non-compliance is a complex problem in recreational fisheries management, having the potential to evoke uncertainty for conservation and socio-ecological outcomes and to undermine management efforts. Understanding compliance behaviour in recreational fisheries is thus of great policy and management relevance. Compliance is typically framed as a binary issue, wherein fishers are either compliant or not, with substantial research directed at measuring and identifying compliance (Sutinen & Kuperan 1999; Honneland 1999; Thomas et al. 2016; Bergseth et al. 2017). Increasingly attention has also been focussed towards understanding the drivers and motivations of compliant and non-compliant behaviours (Boonstra et al. 2017) with several theories being proposed to explain why individuals engage in compliant behaviours (Bottoms 2002).

For example, instrumental theories suggest that the decision of whether to comply or not is based on self-interested calculations about the expected costs and benefits of compliance, and that non-compliance occurs because the cost outweigh the benefits (Becker, 1968). Rules and regulations for recreational fishing are traditionally designed and implemented based on the assumption that fishers are instrumental actors (Bova et al. 2017) with reported instances of improved compliance with more enforcement (Brouwer et al. 1997; Gigliotti & Taylor 2004). Normative theories, on the other hand, argue intrinsic values, such as an individual's perceptions of the legitimacy and fairness of rules, are crucial to fishers' decisions about compliance (Tyler 1997; Grimes 2006; Viteri & Chávez 2007; Tyler 2006). In accordance to this theory, there are cases of high compliance where there is weak enforcement and low penalties due to established normative behavioural drivers (Gezelius 2003; Gezelius 2002; Sutinen & Kuperan 1999).

In addition to instrumental and normative drivers, the literature suggests that psycho-social characteristics of individuals, such as attitudes, personality traits, and specific values towards the good in question, are important factors determining the patterns in individual compliance behaviour (Tyler 2006) (Examples presented in Table 1). For example, individuals' risk preferences have been found to be correlated with compliance with fisheries regulations (Brick et al. 2012). Other key psycho-social characteristics that have been attributed to compliance behaviour are social norms, such as morality and social reputation. There are several examples drawn from fisheries as well as wider literature that

build a strong case for the application of social norms in fisheries compliance management (Thomas et al. 2016; Sutinen & Kuperan 1999; Kuperan & Sutinen 1998). Another psycho-social characteristic influencing compliance behaviour is expectation of others' compliance behaviour as it reflects social perceptions (Bergseth & Roscher 2018). Often expectation of others' compliance behaviour will reflect an individual's own behaviour. The expectation of others' behaviour is regularly over-estimated, for example fishers who poach may also overestimate the prevalence of poaching (Bergseth and Roscher, 2018; Rimal and Real, 2005; Berkowitz, 2005). Other psycho-social characteristics are ecological values and personality types. Environmental ethics literature suggests that having strong ecological values should render high compliance rates where non-compliance would result in some form of environmental degradation (Brennan and Lo, 2002; Nuyen, 2011). The relationships between personality types and complaince behaviours is not prevelant in fisheries compliance literature. However, personalty types, such as openness, extraversion and neuroticism, have been linked with rates of policy violations (McBride et al. 2012) within other compliance literatures.

The overall aim of this chapter is to examine what psycho-social characteristics of individuals are associated with responses to instrumental and normative management incentives in a recreational fisheries context. While there is literature reviewing and testing some of the characteristics mentioned relating to compliance behaviours in fishing and non-fishing contexts, there is a gap in the literature exploring these characteristics concurrently within a controlled experimental setting. To achieve this aim, we conducted a laboratory-based economic experiment in which participants faced four hypothetical fishery scenarios where compliance is measured in terms of whether participants exceed a catch limit. The fishing scenarios use a combination of normative and instrumental incentives to encourage compliance behaviour with a catch limit. Building on the results of Mackay et al. (2019) which presents the results for each of the four scenarios, here we examine both consistency and variation in behaviour across the four scenarios. In doing so we can isolate the effects of an instrumental and normative compliance incentive in both a low deterrence and a high deterrence context. The implication of such a study will contribute to the gap in identifying the patterns in those who are consistently compliant, those who free-ride, and those who are influenced as intended by improving compliant behaviour for different incentives.

Table 4.1 Brief overview of psycho-social characteristics influencing compliance behaviour in fisheries and other contexts

Characteristic	Context	Findings	Literature Cited
Expectation of behaviour of others	Non- compliance in marine reserves	Expectation of others reflect their own	(Bergseth & Roscher 2018)
	Alcohol consumption behaviour	Expectations of others relate to behavioural intentions and often is over estimated	(Rimal & Real 2005; Berkowitz 2005)
	Dictator game experiment testing selfishness or fairness	Empirical expectations about other choices significantly predict one's own choice	(Bicchieri & Xiao 2009)
Social norms	Empirical testing of compliance models on recreational fishers' compliance behaviour	Norms are better at predicting compliant behaviour in recreational fisheries than instrumental drivers	(Thomas et al. 2016)
	Empirical testing of norms on littering behaviour	Empirical studies of norm conformity show that focusing people on an existing norm is an important step toward compliance	(Reno et al. 1993; Cialdini et al. 1990)
	Fishers compliance behaviour model development	Fisheries compliance models including morality and social influence to better encompass compliant behaviour	(Kuperan & Sutinen 1998; Sutinen & Kuperan 1999)
Ecological values	Meta-analysis on pro-environmental behaviour	Ecological values and attitudes are key driver of environmental behaviour	(Ones et al. 2015; Dunlap & Van Liere 1978; Stern & Dietz 1994)
	Philosophical argument on link between ecological ethics and behaviour	Environmental ethics and the moral relationship of human beings to, and the value and moral status of, the environment and its non-human contents	(Nuyen 2011; Brennan & Lo 2002)
Personality Type	Review of agreeableness literature and performance in group game	Compliant behaviour and co-operation linked to agreeableness	(Digman & Takemoto-Chogk 1981; Graziano et al. 1997)
	Review paper on agreeableness	Agreeableness linked to altruism and prosocial behaviour	(Graziano & Eisenberg 1997)
	Meta-analysis on personality types	Deviousness linked to conscientiousness	(Salgado 2004)
	Study on behaviour of steroid users	Impulsivity - obtained higher scores on openness and neuroticism, although they presented lower scores on extraversion compared to the non-user group	(Garcia-Argibay 2019; Fielden et al. 2015)
	Empirical study on characteristics of employee compliance with cybersecurity policies	More open individuals are less likely to violate cybersecurity policies. More Extroverted individuals are more likely to violate cybersecurity policies. More Neurotic individuals are less likely to violate cybersecurity policies	(McBride et al. 2012)
Risk Preferences	Meta-analysis on pro-environmental behaviour	Risk-taking related to taking initiative for pro-environmental behaviour when going against status-quo	(Ones et al. 2015)
	Discrete choice experiment on fisher behaviours	Risk-averse fishers would be expected to choose stable alternatives, while risk-seekers would select more variable options provided these are associated with higher expected returns.	(Girardin et al. 2017;Brick et al. 2012)

4.2. Methods

4.2.1 Compliance decision data collection

We collected compliance decision data by running an economic experiment in which student participants faced four hypothetical scenarios in a recreational fishery context (Fig. 1). At the start of each session, participants were provided an information sheet and consent form, in accordance with ethics approval from the Tasmania Social Sciences Human Research Ethical Committee (Ethics Ref: H0016420). A detailed description of the experimental design and procedure is provided in Mackay *et al.*, (2019).

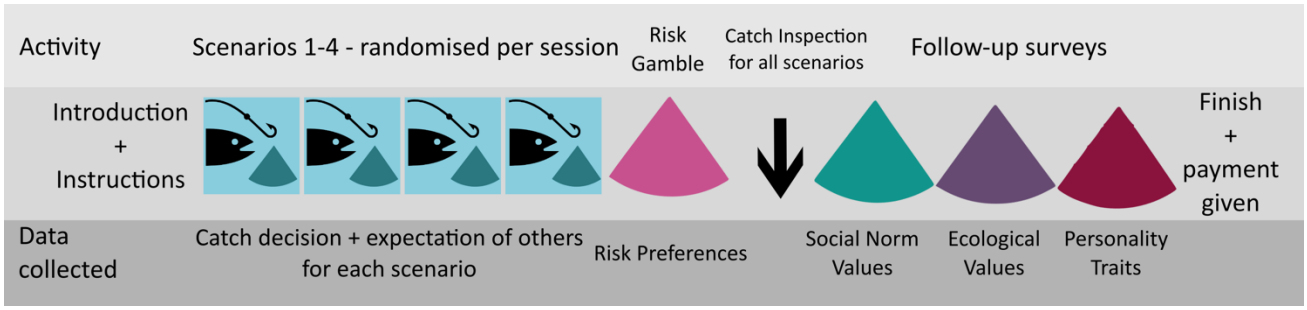

Figure 4.1 Sequence of data collection within experiment

In short, the experiment was designed to reflect the common pool resource context of recreational fishing with groups of six participants fishing individualistically from the same resource. This design is a standard static common pool resource game used in economic experiments (Castillo et al. 2011; Cardenas 2011). The experiment was run for 20 sessions with 120 student participants (i.e., 6 students $\times$ 20 sessions) at the University of Tasmania, Australia from 12 May to 2 June 2017. For each session, a group of six participants earned money by 'catching fish', which reflects the enjoyment fishers receive from going fishing. The amount they earned was based on how many fish they decided to catch and the group total catch. Specifically, as each person caught more fish, they earned more money, however, as the group's total catch increased *ceteris paribus*, the individual's reward for catching additional fish decreased. To measure compliance, we set an individual catch limit of two fish, but each fisher had the option to catch up to five fish in each fishing scenario. Catch equal to or below the catch limit was categorised as compliant and catch higher than the limit was non-compliant.

We encouraged compliance with the catch limit using a combination of two management incentives, specifically an instrumental and a normative[4] incentive, resulting in four scenarios (Table 2). These were delivered through regulation reminders prior to catch decisions for each scenario. The

[4] This was referred to as a 'descriptive social norm nudge' in Chapter 3. To avoid repetition on literature of Nudge Theory hereafter we refer to it as a 'normative management incentive'.

instrumental management incentive was applied by setting the probability of having the catch inspected at either 5% or 20% to create low and high levels of deterrence. If inspected and found to have caught more fish than the limit, the participant received a payoff of zero. The normative management incentive was framed around a descriptive social norm. The norm depicted the catch of a typical fisher in a hypothetical fishery and was given alongside the reminder of the catch limit and level of deterrence (Table 2). The exact wording of the normative message was; "according to last year's data the average fisher chose to catch only ONE (1) fish". The experiment is a within-subject design in which each participant took part in all four fishery scenarios. To mitigate the potential ordering effect, the order of the scenarios was randomised for each session.

Table 4.2 Specifications of the fishery scenarios (Adapted from Mackay et al.(2019))

Fishery scenario	**Level of deterrence**	**Normative message included**	**Regulation reminder statement**
Scenario 1	5%	No	There is a catch limit of TWO (2) fish. There is a 5% chance that you will come across an inspector on your fishing trip who will be checking if you are within the catch limit.
Scenario 2	5%	Yes	There is a catch limit of TWO (2) fish, but according to last year's data the average fisher chose to catch only ONE (1) fish. There is a 5% chance that you will come across an inspector on your fishing trip who will be checking if you are within the catch limit.
Scenario 3	20%	No	There is a catch limit of TWO (2) fish. There is a 20% chance that you will come across an inspector on your fishing trip who will be checking if you are within the catch limit.
Scenario 4	20%	Yes	There is a catch limit of TWO (2) fish, but according to last year's data the average fisher chose to catch only ONE (1) fish. There is a 20% chance that you will come across an inspector on your fishing trip who will be checking if you are within the catch limit.

In this chapter, our interest is in understanding the association between individual's psycho-social characteristics and their response to management incentives aimed at improving compliance outcomes. Specifically, we draw on the fishery scenarios to define three compliance cases, each comprising a base scenario and a comparison scenario in which either a normative or instrumental incentive is applied (Fig. 2). For compliance case 1, we compare behaviours with and without a normative incentive in a low deterrence context (Scenario 1 and Scenario 2 in Table 2). For compliance case 2, we compare behaviours with and without the normative incentive in a high deterrence context (Scenario 3 and Scenario 4 in Table 2). The third compliance case observes the influence of an increase in deterrence without the normative incentive (Scenario 1 and Scenario 3 in Table 2).

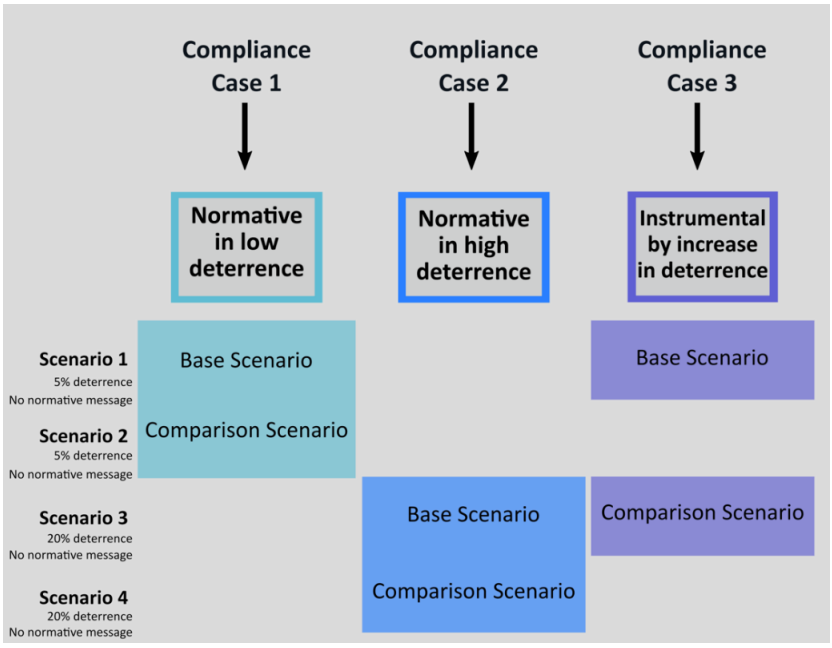

Figure 4.2 Fishery compliance cases. Using the four experimental fishery scenarios three compliance cases are defined by comparing compliance decisions in a base scenario and a comparison scenario. The three compliance cases are :1) normative incentive in a low deterrence context, 2) normative incentive in a high deterrence context, and, 3) an instrumental incentive via an increase in deterrence.

4.2.2 Compliance response groups

We constructed the categorical compliance response variable based on participants compliance decisions within the base scenario and comparison scenario (Fig. 3a) resulting in four nominal categories, namely; i) the *compliers*, ii) the *free-riders*, iii) the *incentivized*, and iv) the *non-compliers*. First, the compliers are those who were consistently compliant for both base and comparison scenarios. The free-riders are those who were compliant in the base scenario and non-compliant in the comparison scenario. The participants who behaved this way are named the free-riders as they have responded to the incentive in an unintended way, possibly in an attempt to maximise payoff on the assumption that others will comply in response to the management incentive resulting in their own increased catch yielding a higher return. Third, the incentivized, who were non-compliant in the base scenario and compliant in the comparison scenario, are named as such as they have responded as intended to the management incentive. The final group, the non-compliers, were consistently non-compliant across both scenarios. Each of the four compliance response groups are potentially characterised by different psycho social-factors which is shown conceptually in Figure 3b) and is the hypothesis empirically tested in this chapter to answer the overall research question.

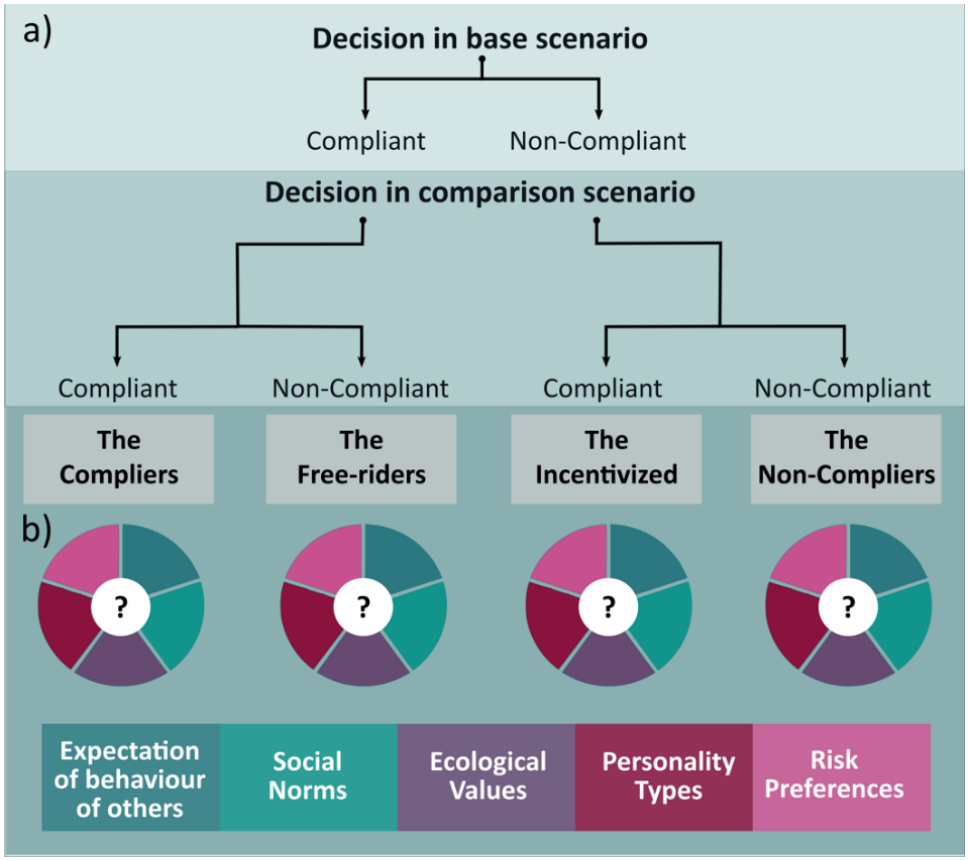

Figure 4.3 Conceptual model of the research procedure. (a) Compliance decisions made in the base and comparison scenarios define the four compliance response groups (the compliers, the free-riders, the incentivized, and the non-compliers. (b) The research aims to identify a pattern in the five psycho-social characteristics of individuals in the four compliance response groups.

The number of members in each compliance response group varies for the three compliance cases (Table 3). When the normative incentive is applied in a low deterrence context, the non-compliers formed the largest group (64). When the same normative incentive was applied in a high deterrence context, the largest group (63) were the compliers. The free-riders are the smallest group (< 10%) across all three compliance cases. Individuals may respond either consistently or differently to different management incentives. For the compliers, 28 out of the 120 participants were consistently compliant across all compliance cases, whereas 27 of the 120 were consistently non-compliant. The incentivized and the free-riders were less consistent across the three compliance cases, only 2 out of the 120 people were consistent free-riders for all three compliance incentives, and none were consistently incentivized.

Table 4.3 Distribution of the number of participants within the four compliance groups for each of the compliance cases

Compliance Response Group	Compliance response		Compliance case		
	Base scenario	Comparison scenario	(1) Normative in low deterrence	(2) Normative in high deterrence	(3) Instrumental by increase in deterrence
The compliers	Comply	Comply	30	63	33
The free-riders	Comply	Non-Comply	7	11	4
The incentivized	Non-Comply	Comply	19	15	41
The non- compliers	Non-Comply	Non-Comply	64	31	42

There is a chance that the order in which the scenarios were played will influence the responses and consequently the compliance response groupings. For example, the comparison scenario could come before the base scenario for each of the cases due to the randomised order participants played the game. Therefore, to account for any ordering effect within these groupings we checked the representativeness of the full data set with two sub-samples. We did this by examining whether there is a statically significant difference in the proportion of each compliance response group for the full sample and the sub-samples. The first sub-sample comprised of data from the first two scenarios played and only the responses that were in the order of base scenario then comparison scenario were included (i.e. scenario 1 followed by scenario 2 would be included as data for case 1, scenario 3 followed by scenario 4 would be included as data for case 2, scenario 1 followed by scenario 3 would be included as data for case 3). The second sub-sample comprised data from all four scenarios but only responses that were in the correct order were included (i.e. if a comparison scenario came before a base scenario it would not be included). These comparisons show that there is no statistical difference between either of the sub-samples and the full data set, suggesting that the randomised order of scenarios did not have an effect on responses and therefore compliance response groupings. The proportions for each of the sub-samples and the results of the proportional comparison statistical tests are found in Appendix 4A.

4.2.3 Psycho-social data

In addition to the compliance decisions that participants made in the economic experiment, we collected information for each participant's psycho-social makeup that might be associated to their compliance decisions based on a review of the literature (Table 1). The timing of data collection is shown in Figure 1. The psycho-social characteristics considered in this chapter were (1) expectation of behaviour of others, (2) social norms, (3) ecological values, (4) personality types, and (5) risk preferences. A description of the variables relating to each of the five psycho-social characteristics is provided in Table 4.

Expectations of behaviour of others

In the experiment, and for each scenario, participants were asked about their expectation of the number of others they thought would not comply. They were asked this question at the same time as they determined the number of fish they were going to catch. Specifically, we asked "How many of the others in the group do you think will exceed the catch limit?". We used this data to create two variables that capture in time expectations of others' behaviours in both the base scenario and comparison scenario for each fishery compliance case.

Social norms

Participants were asked 14 questions on a 5-point Likert scale that make up the Social Norms Espousal Scale (SNES) proposed by Bizer et al. (2014) (Appendix 4B). This survey is used to assess individual differences in the extent to which people believe in and value social norms. Within this survey participants are asked to rate the extent to which the statements were characteristic of them. The statements are framed generally around the importance and influence of social norms (e.g. statement 1: I go out of my way to follow social norms). Individual question scores are summed and the total is ranked on a scale representing participants' values on a low to high value of social norms scale.

Ecological values

The New Ecological Paradigm (NEP) is a 5-point Likert scale survey to measure the environmental concern of people. We used the revised version proposed by Anderson (2012), which was originally developed by Dunlap and Van Liere to assess ''primitive beliefs' about the nature of the earth and humanity's relationship with it" (1978:427). The NEP scale is made up of 15 statements (Appendix 4C), within which three questions represent each of the five hypothesised facets of an ecological worldview, namely i) reality of limits to growth, ii) anti-anthropocentrism, iii) the fragility of nature's balance, iv) rejection of human, and v) possibility of an ecocrisis (Dunlap et al. 2000). The intention of the survey is to develop a scale of ecological values from low ecological paradigm/ high social

paradigm to high ecological paradigm/ low social paradigm. However, this scale is only recommended for use when the result of one question is consistent with the results of the remaining questions (i.e. have a high corrected item total correlation). The responses were varied (Appendix 4C) and therefore we did not use the summed scores from the survey. Instead, we processed the scores for each of the five hypothesised facets of an ecological worldview using a Principal Component Analysis (PCA) to reduce the number of ecological values variables from five (one per facet) to two (Appendix 4C).

Personality types

A widely recognised and accepted taxonomy of personality traits is the 'Big Five' (John et al. 1991). These five broad traits are; agreeableness (*analytical/detached* vs. *friendly/compassionate*), conscientiousness (*easy-going/careless* vs. *efficient/organised*), extraversion (*solitary/reserved* vs. *outgoing/energetic*), neuroticism (*secure/confident* vs. *sensitive/nervous*), and openness (*consistent/cautious* vs. *inventive/curious*). The Big-Five-Inventory was first presented by John et al. (1991) as a self-reported assessment to measure the five traits. In this study, we used a 10-item version of the Big-Five-Inventory (Rammstedt & John 2007) (Appendix 4D). Unlike the measures for social norm and ecological values the scores for personality type are not additive, and so we formed five variables based on their scores for each of the five personality types.

Risk preferences

In addition to the common pool resource game, participants were asked to undertake a paid experimental exercise in which they chose from a range of gambles to elicit their risk preferences. We used the Eckel-Grossman Risk Task (Eckel & Grossman 2002) which is an established way of elucidating risk preferences (Appendix 4E). Participants were asked to undertake the paid gamble in which they chose one of six possible gambles which all have the same 50/50 chance of winning as an assessment of risk attitudes. The gambles range from a safe bet with guaranteed but lower payoff, to a higher risk gamble with a larger payoff. Gambles range from risk averse to risk neutral to risk seeking.

Table 4.4 Summary of psycho-social characteristics

Variable		Definition	Description	
			Low scores	**High Scores**
Expectation of behaviour of others	Base scenario Comparison scenario	An in-time expectation of others' behaviours as a measure of social perceptions	Expect few others to exceed catch limit (other are mostly compliant)	Expect many others to exceed catch limit (others are mostly non-compliant)
Social norms		Measure of the extent in which people believe in and value social norms	Low belief in and value of social norms	High belief in and value of social norms
Ecological values	Rejection of human exemptionalism	Rejection that humans are exempt from the constraints of nature	Regards the world in terms of human values and experiences	Regards the world in terms nature-centred system of values
	Environment-alism	Concerns for environmental protection and improvement of the health of the environment	Low concern for the environment	High concern for the environment
Personality type	Agreeableness	Taxonomy of personality traits	Analytical/ detached	Friendly/ compassionate
	Conscientious-ness		Easy-going/ careless	Efficient/ organized
	Extraversion		Solitary/ reserved	Outgoing/ energetic
	Neuroticism		Secure/ confident	Sensitive/ nervous
	Openness		Consistent/ cautious	Inventive/ curious
Risk preferences		The attitude people hold towards risk	Risk averse	Risk seeking

Note: Descriptive statistics for each of the characteristics is found in Appendix 4F. The possible range for *expectation of behaviour of others* is 0-5, *social norms* is 14-70, each *personality type* is 0-10 and *risk preferences* is 1-5. The two variables of *ecological values* are the PCA scores (Appendix 4C).

4.2.4 Compliance decision and psycho-social data analysis

To understand which of the psycho-social characteristics are related to the four compliance response groups, we used a multinomial (MNL) regression. We estimated a separate model for each of the three compliance cases (Fig. 2) to capture the change in participants' decisions in response to either normative or instrumental incentives. Each of the three models includes all of the psycho-social variables as independent variables. Specifically, for each compliance case *k* (*k* = 1,2,3), we model the probability that individual *j* belongs to compliance response group *m* (*m* = 1,2,3,4) conditional on the psycho-social characteristics of the individual, that is:

$$p_{jkm} = \text{Prob}\left(y_{jk} = m\right) = F_{km}\left(x_j^{'}\beta\right) \quad (1)$$

where y_{jk} is an indicator variable that takes value one if individual *j* belongs to compliance response group *m* and zero otherwise. F_{km} is the cumulative distribution function which lies between zero and one and adds up to one over *m*; i.e., $\sum_m p_{jkm} = 1$ (i.e., each individual must belong to one of the response groups). In equation (1), the psycho-social characteristics of individual *j* is denoted by x_i and β is a vector of the corresponding parameters. We used the multinominal logistic model to estimate the parameters in (1), thereby the cumulative distribution function is given as:

$$F_{km}\left(x_j^{'}\beta\right)=\frac{1}{1+\sum_{m=2}^{4}\exp\left(x_j^{'}\beta_{km}\right)},\ m=1 \quad (2)$$

$$F_{km}\left(x_j^{'}\beta\right)=\frac{\exp\left(x_j^{'}\beta_{km}\right)}{1+\sum_{m=2}^{4}\exp\left(x_j^{'}\beta_{km}\right)},\ m=2,3,4 \quad (3)$$

We set the compliers as the baseline group (m = 1) as the compliers represent the behaviour that we want to emulate (i.e. it reflects the desired compliance behaviour of recreational fishers under all management incentives). Given the baseline compliance response group, the log-odds for all other groups relative to the baseline group can be calculated as a linear combination of the psycho-social factors, such that

$$\ln\left(\frac{\text{Prob}\left(y_{jk}=m^{-}\right)}{\text{Prob}\left(y_{jk}=1\right)}\right)=x_i^{'}\beta_{km^{-}},\ \ m^{-}=2,3,4 \quad (4)$$

Therefore, the signs and statistical significance of each parameter $\beta_{km^{-}}$ indicate whether a change in the psycho-social factor makes an individual's membership to the compliance response group m^{-} more or less likely relative to the baseline group (i.e., compliers). For example, a positive and significant coefficient for a characteristic for one of the compliance response groups would suggest a higher probability of an individual being part of that group. Given the number of independent variables included in the model (Table 4), the multicollinearity between each psycho-social factor is of potential concern in the regression analysis. We calculated the correlation coefficients and confirmed that the correlation between social norms, ecological values and risk preferences is relatively low (<0.25). Where a correlation coefficient was higher than 0.25 for expectation of behaviours of others and personality type, the model results were checked to ensure the multicollinearity did not confound results.

4.3. Results

4.3.1 Expectation of behaviour of others

Among all the psycho-social factors, expectation of behaviour of others in the base scenario was the most frequent significant variable in explaining individuals' membership in the compliance response group for both the instrumental and normative incentives (Table 5). For the non-compliers, the coefficient was positive and significant for compliance cases 1 and 3, indicating that those who have less faith in others to comply with the catch limit in the base scenario are more likely to be non-

compliers. Expectation of behaviour of others in the base scenario was consistently significant and positive for the incentivized group for all the three compliance cases. Conversely, for free-riders, expectation of others in the base scenario was significant for compliance case 2, indicating that those who have less faith in others to comply with the catch limit in the base scenario are less likely to be free-riders.

Expectation of others' behaviour in the comparison scenario was only significant for compliance case 2 (Table 5). This result was found for the non-compliers and the free-riders. For the non-compliers group, the coefficient was positive and significant, suggesting those who have less faith in others to comply in the comparison scenario are more likely to be in the non-compliers group, reflecting their own behaviour as they are non-compliant in this scenario. For free-riders -who were compliant in the base scenario, and non-compliant with the incentive- the result was positive and significant, indicating that those who have less faith in others to comply with catch limit with the management incentive applied are more likely to be in this group. Expectation of others in the comparison scenario was not significant for any management incentive for the incentivized group. This suggests that in the case of a management incentive having the desired effect, the expectation of others is no longer correlated with an individual's own behaviour within the comparison scenario.

Table 4.5 Multinomial logit model results for expectation of others, social norms and ecological values

Psycho-Social Characteristic		**Compliance Case 1 Normative in low deterrence**			**Compliance Case 2 Normative in high deterrence**			**Compliance Case 3 Instrumental**		
		Non-compliers	Free-riders	Incentivized	Non-compliers	Free-riders	Incentivized	Non-compliers	Free-riders	Incentivized
Expectation of behaviours of others	Base scenario	**0.941 *****	-0.173	**0.895 *****	0.311	**-0.785 ***	**0.441 ***	**1.108 *****	0.219	**0.965 *****
		(0.001)	(0.676)	(0.004)	(0.118)	(0.071)	(0.066)	(0.000)	(0.637)	(0.000)
	Comparison scenario	0.221	0.542	-0.42	**0.461 ***	**1.244 *****	0.239	0.23	0.542	-0.246
		(0.387)	(0.215)	(0.131)	(0.059)	(0.006)	(0.438)	(0.322)	(0.184)	(0.325)
Social Norms		0.068	-0.011	0.052	0.022	0.08	0.04	0.072	0.024	**0.081***
		(0.120)	(0.865)	(0.318)	(0.516)	(0.139)	(0.427)	(0.123)	(0.851)	(0.067)
Ecological values	Rejection of human exemptionalism	-0.257	0.003	-0.369	-0.043	-0.096	**-0.438 ***	**-0.479 ***	**-1.267 ****	**-0.498 ****
		(0.244)	(0.993)	(0.149)	(0.812)	(0.746)	(0.084)	(0.064)	(0.036)	(0.037)
	Environmentalism	**-0.629 ****	-0.305	-0.407	-0.05	0.229	-0.075	**-0.725 ****	-0.106	**-0.607 ***
		(0.047)	(0.545)	(0.227)	(0.848)	(0.572)	(0.830)	(0.038)	(0.888)	(0.064)

Note: This table reports the estimates of the coefficients and p-values in parentheses for the three compliance cases. The baseline compliance response group is the compliers. Significant coefficients are bolded, and significance level are: *p<0.1; **p<0.05; ***p<0.01. Full regression results are reported in Appendix 4G.

4.3.2 Social norms

The estimated coefficient of social norms was not significant for the non-compliers or the free-riders for any compliance case (Table 5). The estimated coefficient of social norms was positive and only significant for the incentivized for compliance case 3, suggesting that those who have a high value of social norms are likely to be non-compliant when deterrence is low but compliant with high deterrence. The coefficient of social norms was not significant for the incentivized for the normative message incentives in either a high or low deterrence context which means there is no association between the value of social norms and the influence of a normative message on compliance behaviours.

4.3.3 Ecological values

For the cases where human exemptionalism and environmentalism is a significant predictor variable the direction of the effect is negative, indicating that those with high ecological values are less likely to be part of the response groups they were significant for (Table 5). For compliance case 3, the coefficient of rejection of human exemptionalism was significant for all response groups and environmentalism was significant for two response groups. These results suggest that those with high ecological values are less likely to be part of the groups responding in a way other than complying with an increase in deterrence, which infers compliers have high ecological values. By contrast, rejection of human exemptionalism was not significant for any group for compliance case 1 and for only one group for compliance case 2. This suggests that the link between human exemptionalism and responses to a normative management incentive is weak. Likewise, environmentalism was significant for non-compliers for case 1 and not significant for any groups for case 2, suggesting that the link between environmentalism and a response to a normative management incentive is also weak.

4.3.4 Personality type

The 'Big Five' personality traits that are significant in this analysis all have a negative coefficient (Fig. 4). This means that those who have these personality traits are more likely to be the compliers (i.e., baseline group). The personality traits that are significant, however, vary across both compliance cases and the compliance response group. For example, those with agreeableness, conscientiousness or extraversion as personality traits are less likely to be non-compliers in response to either a normative or an instrumental incentive (Fig. 4). In response to the normative incentive (in compliance case 1 and 2) extraversion and openness were significant for the incentivized and the free-riders, respectively, indicating that those with these personality traits are less likely to be part of these groups and more likely to be the compliers. Finally, in response to the instrumental incentive, the coefficient of

conscientiousness was significant and negative again indicating those with this personality trait are more likely to be compliers than the incentivized.

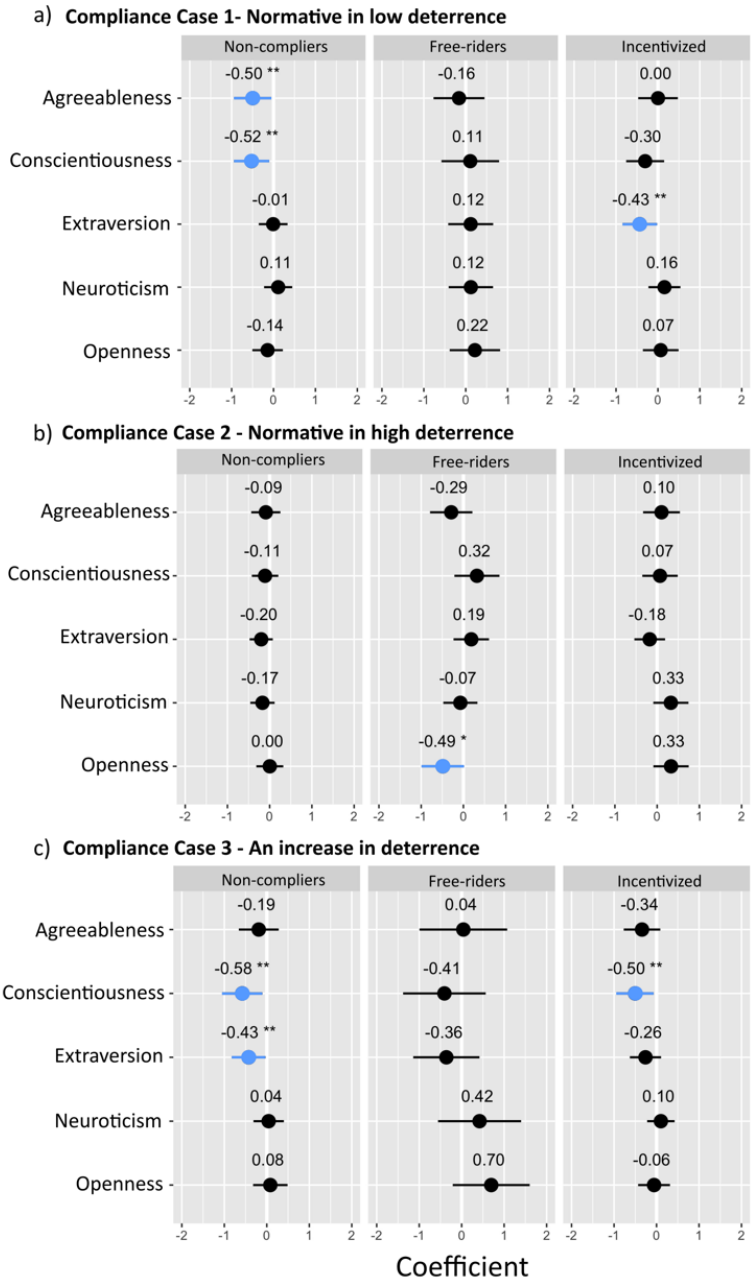

Figure 4.4 Multinomial logit model results for personality types for non-compliers, free-riders, and the incentivized for a) compliance case 1: normative message in low deterrence, b) compliance case 2: normative message in high deterrence, and c) compliance case 3: an increase in deterrence. Coefficients are included, and error bars indicate standard error. Significant coefficients are highlighted in blue, and significance level are: *p<0.1; **p<0.05; ***p<0.01. Full regression results are reported in Appendix 4G.

4.3.5 Risk preferences

Risk preference was significant in explaining respondents' compliance response to both the normative and instrumental incentives (Fig. 5). For non-compliers, risk preference was significant and positive for all compliance cases, suggesting that those who are risk seeking are more likely to be non-compliers regardless of the management incentive applied (Fig. 5). Risk preference was also significant and positive for the incentivized for compliance case 2, suggesting that those who are risk seeking are more likely to be in this group, which may explain why they were non-compliant in the base scenario. Risk preference is significant for the free-riders for compliance case 3. There are fewer significant results for compliance case 1 (normative in low deterrence) compared to the other compliance cases, which may reflect that the risk of being caught in this context is the lowest and therefore not a strong predictor for the incentivized or the free-riders.

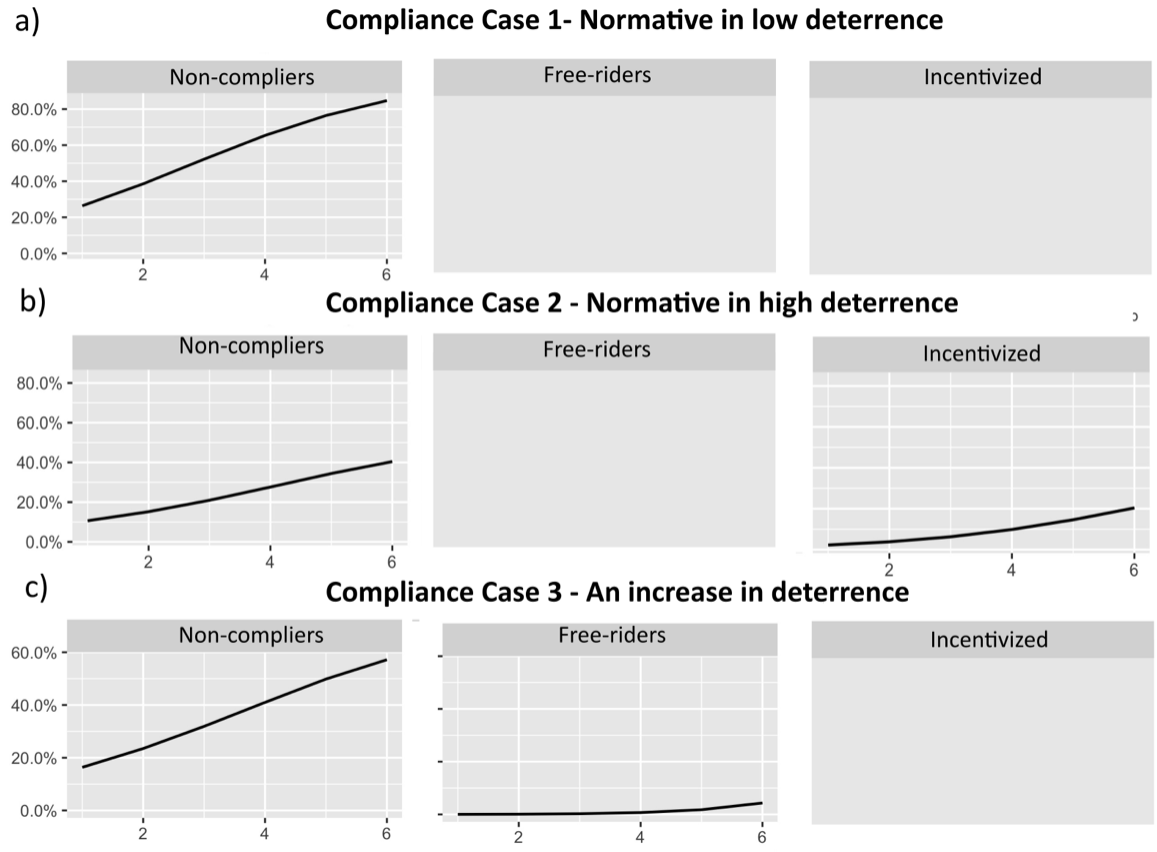

Figure 4.5 Probability plots based on risk preferences for each group for non-compliers, free-riders, and the incentivized for a) compliance case 1: normative message in low deterrence, b) compliance case 2: normative message in high deterrence, and c) compliance case 3: an increase in deterrence. Risk score is along the x-axis and probability of group membership (%) is on the y-axis, non-significant results are left blank. See Appendix 4G for detailed regression results including coefficients and p-values.

4.4 Discussion

While we know that in fisheries people make trade-off decisions between following or breaking rules, it is of interest to determine how people respond to different management incentives. Accurately understanding the different responses to instrumental and normative incentives and highlighting the psycho-social patterns within these responses is highly relevant for fisheries policy. In our laboratory-based economic experiment, in which participants faced four hypothetical fishery scenarios to provide the controlled setting to measure behavioural responses and to remove any potential confounding influences, we were able to shed light on this issue. While this chapter is framed around a recreational fisheries context, the compliance problems faced for other natural resources (Keane et al. 2008) are similar and potentially similar policy opportunities (as discussed below) may apply. In this chapter, we first identified patterns in compliance behaviour. The pattern reveals a group of people who are consistently compliant, a group who are consistently non-compliant, a group who respond counterintuitively, and a group who are incentivized to become compliant (as intended by the management incentive). In this chapter, we further explored how the pattern in compliance behaviour is associated with five psycho-social factors, three of which (perceptions of behaviour of others, social norms, and risk preferences) have separately been explored within the fisheries compliance literature, while two factors (ecological values and personality types) had yet to be explored. While information about these two latter factors is limited within the fisheries compliance literature, our results suggest that they are relevant predictors for individuals' compliance response to different management incentives.

To summarise the findings, we combine results for individual factors into umbrella factors to conceptually present the results in Figure 6. For example, the umbrella factor *expectation of others' behaviour* combines the results of base scenario and comparison scenario, *ecological values* represents both rejection of human exemptionalism and environmentalism and *personality types* includes all five personality factors. The shading of the segments indicates that at least one of the included factors for the umbrella factor is significant (but not necessarily all of them). The aim of this chapter was to compare the role of psycho-social characteristics of individual fishers in explaining responses to an instrumental and normative management incentives. Each of the umbrella factors is statistically significant in explaining compliance behaviour in at least one compliance case and for at least one of the three compliance response groups (Fig. 6). For example, one consistent result across both the normative and instrumental incentive was the relationship between risk preferences and

non-compliance. The *expectation of others' behaviour* was also the most frequently statistically significant factor (in 7 of the 9 cases[5] – dark green shaded segment in Figure 6).

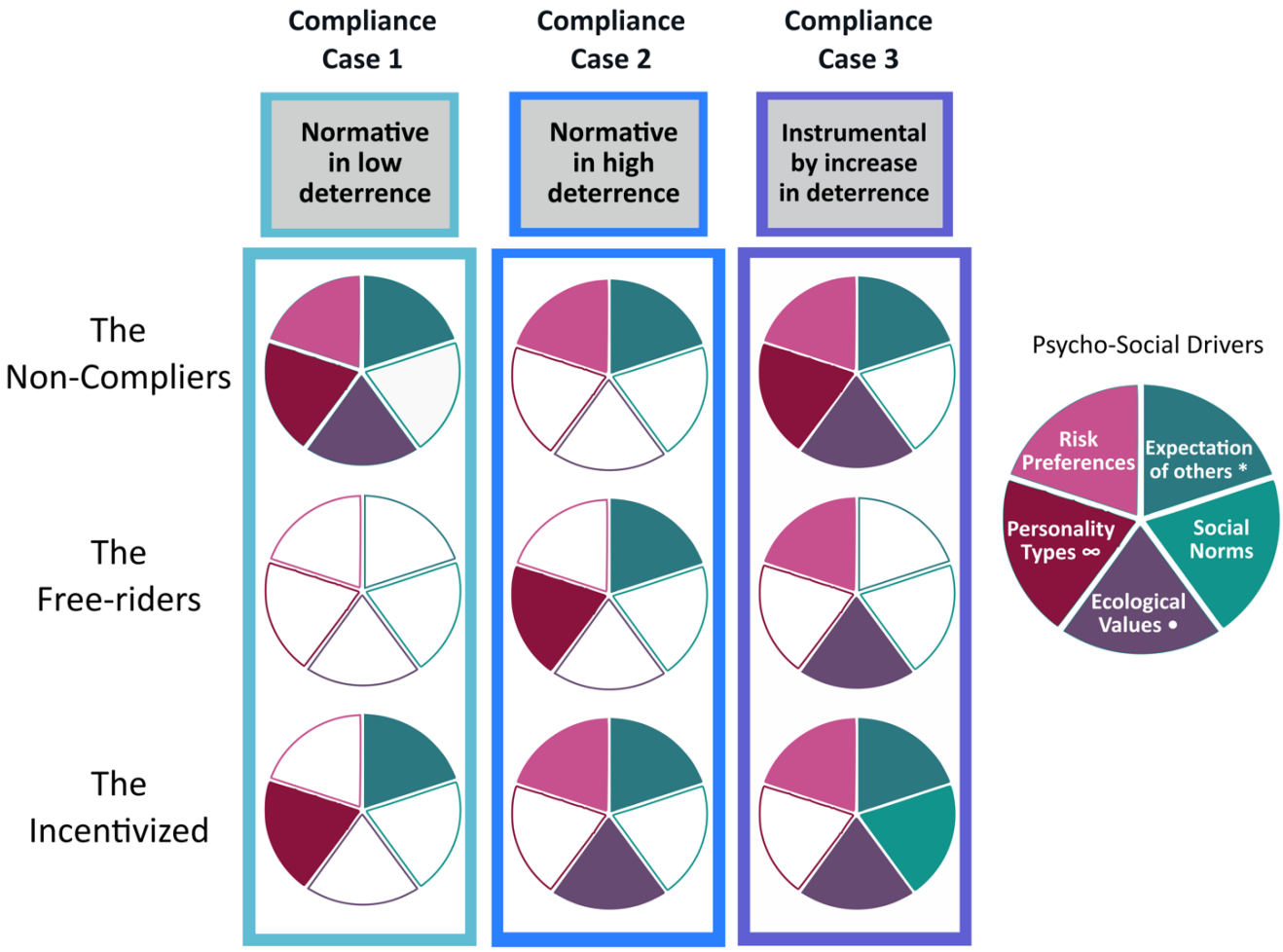

Figure 4.6 Conceptual summary of the results. Shaded segments indicate if one of the factors included in the umbrella factors was significant and left unshaded if not significant. *Expectation of others combines the results of base scenario and comparison scenario, •Ecological values represents both rejection of human exemptionalism and environmentalism and ∞Personality types includes all five personality traits.

Broadly we see that more psycho-social factors were statistically significant in explaining the behaviour of non-compliers and the incentivized compared to the free-riders. Individual's membership in the free-riders is the hardest to predict based on the five psycho-social factors. This may be due to the low number of observations for this group and therefore the results for this group must be interpreted with care. Moreover, we can see that more psycho-social factors explain behavioural responses to an instrumental incentive than a normative incentive (Fig. 6). Ecological

[5] There are a total of nine cases, three response groups (compared to the 'compliers') and three compliance cases.

values, for example, was consistently a significant predictor for responses to an instrumental incentive but not for either of the normative incentives. The results suggest that there is a relationship between having high environmental values and acting consistently compliant because the relationship between ecological values and all other response groups (non-compliers, free-riders, and the incentivized) was negative and significant. That is to say, the compliers have higher environmental values than any other group in response to an instrumental incentive, suggesting that compliance behaviour could be encouraged by increasing environmental values and concern. These results are consistent with the behavioural literature suggesting a link between high environmental values and pro-environmental behaviour (Nuyen 2011; Ones et al. 2015).

Social norms was only significant for the incentivized for the instrumental incentive. Social norms was expected to be a significant predictor, especially for the incentivized in response to the normative incentives. However, we find that social perceptions of others' behaviours are more effective at representing the implicit expectations of an individual. The results for expectation of others' behaviour suggests that when participants are non-compliant they think others are also exceeding the catch limit. This behaviour, also known as false consensus or pluralistic ignorance, can lead to misperceived norms and reinforce non-compliant behaviour (Rimal and Real, 2005: Berkowitz, 2005). Targeting these misconceptions results in a more accurate normative feedback with expected improved compliance (Bergseth & Roscher 2018). This can be achieved through highlighting pro-compliance perceptions and norms of fishers as well as reporting consequences of non-compliant behaviour (Bova et al. 2017; Bergseth & Roscher 2018). This could resemble social punishment through shame and moral unacceptance of non-compliance as well as traditional deterrence such as fines (Thomas et al. 2016; Mackay et al. 2018). The SNES survey is intended to assess individual differences in the extent to which people believe in and value social norms, however from our results it was related to the response to the instrumental incentive. Although instrumental incentives are expected to crowd out social or moral norms (Kroneberg et al. 2010; Barile et al. 2015), we find that high social norms value complements the effectiveness of the instrumental compliance incentive.

There were differences in behavioural responses to an instrumental incentive and a normative incentive for different personality traits. For the instrumental incentive introversion was inferred for non-compliers for the case of an increase in deterrence. Non-compliant behaviour has been found to be associated with introversion but only when combined with high neuroticism (Gudjonsson et al. 2004), however, neuroticism was not a significant personal trait in our results. The results also indicated a low likelihood of being non-compliant or the incentivized in response to an increase in deterrence for those with high conscientiousness. Low conscientiousness is associated with

impulsivity (Sharma et al. 2014). This suggests that impulsivity may be related to non-compliance when there is a low chance of being caught but it is over shadowed when there is a higher chance of being caught.

Low conscientiousness is also linked to deviousness (Salgado 2004), which may explain why the trait is found to be associated with those who are non-compliant in response to the normative incentive in a low deterrence context. However, we did not find this result for the normative incentive in a high deterrence context, suggesting that the risk of being caught may overshadow the tendency to be devious. The only personality type that was significant for normative incentive in high deterrence was openness. Specifically, our result suggests that those who are open are unlikely to be free-riders for the normative incentive in a high deterrence context. This may infer that free-riders have low openness as part of their personalities. A low score for openness represents a consistent and cautious personality which would be unexpected for the free-riders as they become non-compliant and at risk of a penalty. This result is somewhat counterintuitive, but may be associated with the low number of observations for this group.

For normative incentive in a low deterrence context, personality types were more frequently statistically significant. The results for non-compliers for this management incentive infer low agreeableness and low conscientiousness. People with low agreeableness tend to be less cooperative and more competitive in groups (Graziano & Eisenberg 1997), which may explain the non-compliant behaviour as participants may be acting competitively to make more money in the experiment. The results may reflect that the compliers are more agreeable which has been linked to prosocial and altruistic behaviours (Graziano et al. 1997). Introversion is expected to correlate with compliance behaviour since a typical introvert is depicted as a responsible person who is expected to be compliant (Gudjonsson et al. 2004). Consistent with the expectation, the results suggest introversion is associated with the incentivized for the case of normative incentives in low deterrence. This suggests that introversion is correlated with compliant behaviour for a normative incentive and non-compliers for an instrumental incentive.

4.5 Future research

In this chapter, we explore what psycho-social characteristics of individuals are associated with responses to instrumental and normative management incentives in a recreational fisheries context, yet there are some caveats to consider when interpreting the results. First, we use a controlled environment via an economic experiment with student participants, which is useful for minimizing potential confounders. However, we recognise that different demographics in a fishery or alternate

natural resource context may result in different conclusions. Second, while we find that the normative message in the experiment changed behaviour, a normative expectation can be strengthened on the belief that others think they should or have an obligation to conform to the norm (Bicchieri & Xiao 2009). We envisage that future work can explore the use of normative messages that are not only based on what the wider group is doing but where the message suggests there is a consciousness of what is accepted by others to strengthen the normative expectations (Reno et al. 1993). We also acknowledge that there are a number of alternative psycho-social drivers to explore in relation to compliance responses. For example, while we found links between personality traits that are linked to impulsivity, it may be worth exploring the link between behaviour and impulsivity directly (Maccallum et al. 2007). Additionally, the role of self-control has been explored in the trade-off between short term temptation to be selfish and long term pro-social behaviour (Martinsson et al. 2010), which would be highly applicable to natural resource use and actions impacting the global climate. Finally, there are several findings from this chapter and while we have highlighted the findings that we determined to be the most novel within the fisheries compliance literature, we acknowledge that there are many dimensions to the results and a number of interesting results were not developed in the discussion.

4.6. Conclusion

People respond differently to management incentives and often they respond in a way that is contradictory to expectation. While there are different instrumental and normative incentives that can be used to influence compliance behaviour, the aim of this chapter was to explore the association between individual psycho-social characteristics and compliance responses. We explored five psycho-social factors: expectations of others' behaviour, social norms, ecological values, personality types, and risk preferences. Our results highlight there are different psycho-social factors associated with certain compliance response behaviours. For example, risk seeking is associated with people who can be categorised as non-compliers. There are certain behaviours that are harder to predict, for example for people who behave contrary to the compliance incentive, who we labelled free-riders. We acknowledge findings outside the laboratory experimental context and fishery example may vary from these conclusions, but we offer a number of policy suggestions based on the results of our findings, such as emphasizing the risk of non-compliance and using compliance campaigns that target encouraging environmental concerns. The findings underline that there is significant heterogeneity in the associations between psycho-social make-up and compliance behaviours. Knowledge of this behavioural relationship can progress fisheries management towards increased innovation by encouraging the management of the individual fisher rather than the average fisher.

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Chapter 4 Appendices

Appendix 4A. Sensitivity analysis on ordering effect

Table 4A.1 Comparison of proportions between full sample and two sub-samples to assess any ordering effect

	Normative in low deterrence			Normative in high deterrence			Instrumental		
Compliance Response Group	Full sample	Sub-sample 1	Sub-sample 2	Full sample	Sub-sample 1	Sub-sample 2	Full sample	Sub-sample 1	Sub-sample 2
The compliers	25	16.7	16.7	52.5	0	43.3	27.5	25	13.3
		(0.4431)	(0.3838)			(0.3689)		(0.8535)	(0.1077)
The free-riders	5.8	11.1	8.3	9.2	0	20	3.3	0	0
		(0.3964)	(0.6445)			**(0.0966)***		(0.5244)	(0.3149)
The incentivized	15.8	22.2	20.8	12.5	0	10	34.2	41.7	40
		(0.4981)	(0.5496)			(0.7072)		(0.6046)	(0.5536)
The non-compliers	53.3	50	54.2	25.8	0	26.7	35	33.3	46.7
		(0.7944)	(0.9359)			(0.9202)		(0.9065)	(0.2376)
Number of observations	120	18	24	120	0	30	120	12	30

Note: This table reports the proportion per compliance response group and the p-values in parentheses for comparison of proportions statistical test. Significant coefficients are bolded, and significance level are: *p<0.1; **p<0.05; ***p<0.01.

Appendix 4B: Social Norm Espousal Scale Questionnaire

Participants asked to complete the Social Norm Espousal Scale (SNES) questionnaire (Bizer et al. 2014) after completing the recreational fisheries experiment. Questions with asterisk (*) are reverse coded for the analysis.

Q1. Please indicate how strongly you agree or disagree with each of the statements.

		Strongly Agree	**Agree**	**Unsure**	**Disagree**	**Strongly Disagree**
1	I go out of my way to follow social norms	1	2	3	4	5
2*	People shouldn't always have to follow a set of social rules	1	2	3	4	5
3*	People should always be able to behave as they wish rather than trying to fit the norm	1	2	3	4	5
4	There is a correct way to behave in every situation	1	2	3	4	5
5	If more people followed society's rules, the world would be a better place	1	2	3	4	5
6	People need to follow life's unwritten rules every bit as strictly as they follow the written rules	1	2	3	4	5
7	There are lots of key customs that people should follow as members of society	1	2	3	4	5
8*	The standards that society expects us to meet are far too restrictive	1	2	3	4	5
9	People who do what society expects of them lead happier lives	1	2	3	4	5
10	Our society is built on unwritten rules that members need to follow	1	2	3	4	5
11	I am comfortable only when everyone around me is following society's norms	1	2	3	4	5
12*	We would be happier if we didn't try to follow society's norms	1	2	3	4	5
13*	My idea of a perfect world would be one with few social expectations	1	2	3	4	5
14	I always do my best to follow society's rules	1	2	3	4	5

Appendix 4C: New Ecological Paradigm Scale Questionnaire

Participants asked to complete the New Ecological Paradigm Scale (NEPS) questionnaire (Dunlap et al. 2000) after completing the recreational fisheries experiment. Questions with asterisk (*) are reverse coded for the analysis.

Q2. Please indicate how strongly you agree or disagree with each of the statements.

		Strongly Agree	**Agree**	**Uncertain**	**Disagree**	**Strongly Disagree**	**Facet of ecological worldview§**
1*	We are approaching the limit of the number of people the Earth can support	1	2	3	4	5	1
2	Humans have the right to modify the natural environment to suit their needs	1	2	3	4	5	2
3*	When humans interfere with nature it often produces disastrous consequences	1	2	3	4	5	3
4	Human innovation will ensure that we do not make the Earth unlivable	1	2	3	4	5	4
5*	Humans are seriously abusing the environment	1	2	3	4	5	5
6	The Earth has plenty of natural resources if we just learn how to develop them	1	2	3	4	5	1
7*	Plants and animals have as much right as humans to exist	1	2	3	4	5	2
8	The balance of nature is strong enough to cope with the impacts of modern industrial nations	1	2	3	4	5	3
9*	Despite our special abilities, humans are still subject to the laws of nature	1	2	3	4	5	4
10	The so-called “ecological crisis” facing humankind has been greatly exaggerated	1	2	3	4	5	5
11*	The Earth is like a spaceship with very limited room and resources	1	2	3	4	5	1
12	Humans were meant to rule over the rest of nature	1	2	3	4	5	2
13*	The balance of nature is very delicate and easily upset	1	2	3	4	5	3
14	Humans will eventually learn enough about how nature works to be able to control it	1	2	3	4	5	4
15*	If things continue on their present course, we will soon experience a major ecological catastrophe	1	2	3	4	5	5

§ Facets of an ecological worldview: 1) the reality of limits to growth, 2) anti-anthropocentrism, 3) the fragility of nature’s balance, 4) rejection of exemptionalism, and 5) the possibility of an ecocrisis.

Table 4C.1. Proportional spread of responses for each question in the NESP scale and the corrected item-total correlations (last column)

Question	Strongly Agree	Agree	Unsure	Disagree	Strongly Disagree	r_{i-t}
1	5.8	21.7	15.8	27.5	29.2	0.56
2	3.3	17.5	20.8	40.8	17.5	0.46
3	0.0	9.2	15.0	45.0	30.8	0.33
4	9.2	23.3	46.7	20.0	0.8	0.10
5	0.0	3.3	11.7	39.2	45.8	0.62
6	20.0	44.2	13.3	19.2	3.3	0.07
7	0.0	5.8	5.8	39.2	49.2	0.35
8	0.8	8.3	17.5	40.8	32.5	0.47
9	0.0	0.8	9.2	53.3	36.7	0.09
10	3.3	5.8	15.0	42.5	33.3	0.34
11	3.3	12.5	14.2	46.7	23.3	0.42
12	4.2	10.8	14.2	25.0	45.8	0.43
13	0.0	17.5	24.2	39.2	19.2	0.36
14	6.7	15.8	34.2	29.2	14.2	0.23
15	1.7	5.0	13.3	36.7	43.3	0.52

Due to the varied corrected item-total correlation, the responses instead were grouped into the five hypothesised facets of an ecological worldview : 1) the reality of limits to growth, 2) anti-anthropocentrism, 3) the fragility of nature's balance, 4) rejection of exemptionalism, and 5) the possibility of an ecocrisis. (Dunlap et al. 2000) and participants had a score for each. We then ran a PCA on the scores of the five hypothesised facets of an ecological worldview to reduce the number of independent variables (Fig. C1). The first component (which explained 45.2% of the data) was defined by one of the five facets; "rejection of human exemptionalism". Human exemptionalism represents the belief that humans are different to all other animal and exempt from the constraints of nature, and the world is interpreted more in terms of human values and experiences (Wallhagen & Magnusson 2017). The second component (which explained 20.7% of the data) was defined by the other four hypothetical facets. We summarised the four facets to represent environmentalism. Individual loadings on these components were used as two variables representing ecological values in our model.

Figure 4C.1. Principle component analysis plot of the scores of the five hypothesised facets of an ecological worldview (represented by the red arrows) to reduce the number of independent variables for ecological values from five to two.

Appendix 4D: Personality Test Questionnaire

Participants asked to complete a Big-Five personality test questionnaire (Rammstedt & John 2007) after completing the recreational fisheries experiment. Questions with asterisk (*) are reverse coded for the analysis.

Q3. How well do the following statements describe your personality?

	I see myself as someone who…	**Strongly Agree**	**Agree a little**	**Neither agree nor disagree**	**Disagree a little**	**Strongly Disagree**
1	…is reserved	1	2	3	4	5
2*	…is generally trusting	1	2	3	4	5
3	…tends to be lazy	1	2	3	4	5
4	…is relaxed, handles stress well	1	2	3	4	5
5	…has few artistic interests	1	2	3	4	5
6*	…is outgoing, sociable	1	2	3	4	5
7	…tends to find fault with others	1	2	3	4	5
8*	…does a thorough job	1	2	3	4	5
9*	…gets nervous easily	1	2	3	4	5
10*	…has an active imagination	1	2	3	4	5

Appendix E: Risk Preferences Assessment

Participants took part in a paid experimental gamble taken from Dave et al. (2010) after the fishery experiment and before completed the surveys.

You will select one of the six different gambles listed below by placing an X in the appropriate box.

Each gamble has two possible outcomes (Heads or Tails) with a 50/50 chance of either occurring. At the end of the session, a coin will be flipped to determine which outcome will occur.

The amount you will be paid for this task is determined by:

- which of the six gambles you select; and
- which of the two possible outcomes (Heads or Tails) occurs.

For example, if you select Gamble 4 and Heads occurs, you will receive 52 Experimental Enjoyment Units and be paid $5.20. If Tails occurs, you will receive 16 Experimental Enjoyment Units and be paid $1.60.

	Outcome of Coin Flip	Payoff (in Experimental Enjoyment Units)	Chances	Your selection **Mark only one by placing an X in appropriate box**
Gamble 1	Tails	28	50%	
	Heads	28	50%	
Gamble 2	Tails	24	50%	
	Heads	36	50%	
Gamble 3	Tails	20	50%	
	Heads	44	50%	
Gamble 4	Tails	16	50%	
	Heads	52	50%	
Gamble 5	Tails	12	50%	
	Heads	60	50%	
Gamble 6	Tails	2	50%	
	Heads	70	50%	

Appendix 4F. Descriptive Statistics for psycho-social characteristics

Table E.1 Descriptive statistics for psycho-social characteristics

	Expectation of behaviour of others				**Social Norms**	**Ecological Values**		**Personality Types**					**Risk Preferences**
	Expectations of others (scenario 1)	Expectations of others (scenario 2)	Expectations of others (scenario 3)	Expectations of others (scenario 4)		Rejection of human exemptionalism	Environmentalism	Agreeableness	Conscientiousness	Extraversion	Neuroticism	Openness	
Mean	3.13	2.50	1.48	1.34	44.25	0	0	7.19	6.65	6.13	6.11	7.16	3.77
Standard Error	0.15	0.15	0.13	0.12	0.69	0.14	0.09	0.15	0.16	0.19	0.18	0.16	0.16
Median	3	3	1	1	44.50	0.21	0	7	7	6	6	7	3
Standard Deviation	1.60	1.64	1.40	1.29	7.55	1.51	1.02	1.68	1.73	2.08	1.95	1.76	1.70
Sample Variance	2.57	2.71	1.97	1.66	56.95	2.28	1.04	2.81	3	4.34	3.79	3.11	2.89
Minimum	0	0	0	0	23	-3.84	-2.81	3	2	2	2	2	1
Maximum	5	5	6	4	63	3.20	2.68	10	10	10	10	10	6

Appendix 4G. Multinomial logit results

Table G.1. Multinomial model results on responses to normative and instrumental incentives

Psycho-Social Characteristic		Compliance Case 1 Normative in low deterrence			Compliance Case 2 Normative in high deterrence			Compliance Case 3 Instrumental		
		Non-compliers	Free-riders	Incentivized	Non-compliers	Free-riders	Incentivized	Non-compliers	Free-riders	Incentivized
Expectation of behaviour of others	Base scenario	**0.941*** ** (0.001)	-0.173 (0.676)	**0.895*** ** (0.004)	0.311 (0.118)	**-0.785*** (0.071)	**0.441*** (0.066)	**1.108*** ** (0.000)	0.219 (0.637)	**0.965*** ** (0.000)
	Comparison scenario	0.221 (0.387)	0.542 (0.215)	-0.42 (0.131)	**0.461*** (0.059)	**1.244*** ** (0.006)	0.239 (0.438)	0.23 (0.322)	0.542 (0.184)	-0.246 (0.325)
Social Norms		0.068 (0.120)	-0.011 (0.865)	0.052 (0.318)	0.022 (0.516)	0.08 (0.139)	0.04 (0.427)	0.072 (0.123)	0.024 (0.851)	**0.081*** (0.067)
Ecological values	Rejection of human exemptionalism	-0.257 (0.244)	0.003 (0.993)	-0.369 (0.149)	-0.043 (0.812)	-0.096 (0.746)	**-0.438*** (0.084)	**-0.479*** (0.064)	**-1.267** ** (0.036)	**-0.498** ** (0.037)
	Environmentalism	**-0.629** ** (0.047)	-0.305 (0.545)	-0.407 (0.227)	-0.05 (0.848)	0.229 (0.572)	-0.075 (0.830)	**-0.725** ** (0.038)	-0.106 (0.888)	**-0.607*** (0.064)
Personality Type	Agreeableness	**-0.496** ** (0.029)	-0.16 (0.606)	0.002 (0.992)	-0.091 (0.607)	-0.288 (0.260)	0.104 (0.641)	-0.189 (0.428)	0.04 (0.940)	-0.342 (0.119)
	Conscientiousness	**-0.525** ** (0.014)	0.108 (0.757)	-0.305 (0.187)	-0.109 (0.496)	0.321 (0.238)	0.068 (0.749)	**-0.578** ** (0.017)	-0.406 (0.413)	**-0.504** ** (0.024)
	Extraversion	-0.009 (0.958)	0.118 (0.666)	**-0.433** ** (0.039)	-0.2 (0.155)	0.187 (0.384)	-0.175 (0.345)	**-0.427** ** (0.035)	-0.36 (0.365)	-0.26 (0.165)
	Neuroticism	0.111 (0.520)	0.122 (0.651)	0.156 (0.423)	-0.17 (0.246)	-0.071 (0.729)	0.326 (0.126)	0.044 (0.812)	0.422 (0.398)	0.103 (0.534)
	Openness	-0.142 (0.444)	0.219 (0.475)	0.067 (0.758)	0.003 (0.983)	**-0.487*** (0.056)	0.33 (0.123)	0.083 (0.689)	0.696 (0.132)	-0.058 (0.763)
Risk preferences		**0.467** ** (0.020)	-0.215 (0.508)	-0.149 (0.518)	**0.438*** ** (0.008)	0.146 (0.545)	**0.611** ** (0.014)	**0.650*** ** (0.004)	**1.401** ** (0.044)	0.335 (0.103)
Constant		0.366 (0.905)	-3.732 (0.444)	-0.528 (0.884)	-0.938 (0.741)	-4.388 (0.331)	-11.432*** (0.008)	-1.515 (0.662)	-14.034 (0.154)	0.803 (0.799)
McFadden's pseudo-R2			0.331			0.214			0.308	
Log-likelihood			-91.47			-110.00			-99.86	
AIC			254.947			292.002			271.729	
Likelihood ratio test (p-value)			**2.943e-07 *** **			**0.002725 ** **			**4.975e-07 *** **	
Number of observations		64	7	19	31	11	15	42	4	41

Note: This table reports the estimates of the coefficients and p-values in parentheses for the three compliance cases. The baseline compliance response group is the compliers. Significant coefficients are bolded, and significance level are: *p<0.1; **p<0.05; ***p<0.01.

Chapter 5 - Determining fishers' divergent management preferences in a consumptive recreational fishery

Chapter 5

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Author	Contribution	%	Signature
MM	Conceived, developed and designed the study; led data collection activities; led data analysis; wrote the manuscript	80	
SY	Contributed to the design and development of the study; contributed data analysis; provided input into the writing of the manuscript	10	
JL	Contributed to the design and development of the study; contributed data analysis; provided input into the writing of the manuscript	10	

5.1 Introduction

Effective evidence-based decision making is an onerous task for recreational fisheries management. Given the rising pressures on fish stocks and multiple benefits generated by recreational fishing, the need for responsible and sustainable recreational fisheries is increasingly recognised (Cooke et al. 2019; van Putten et al. 2017). There is a myriad of policy options for the management of recreational fisheries with varying effectiveness in aspects such as fisher enjoyment, compliance feasibility, and biological stock sustainability. Successful fishery management depends on whether it incorporates various sources of uncertainty, including variability in resource dynamics (Hofmann & Powell 1998), error in reporting, monitoring and assessment (Agnew et al. 2009), and even politicised management decisions (Tsangarides 2007). Moreover, fishers' behaviour contrary to management objectives or expectations is a consistent factor contributing to the divergence between the intended and actual management outcomes (Fulton et al. 2011).

To account for behavioural responses to management changes, an acute understanding of fishers' motivations to participate in the recreational fishery as well as their preferences towards different management tools is necessary. Fundamental to all recreational fishing is that it is a leisure activity (Cooke et al. 2019). As opposed to commercial fisheries in which motivations are predominantly related to economic rewards, motivations vary extensively for recreational fishers (Cooke et al. 2019; Fedler & Ditton 1994). Broadly, recreational fishers can engage in either catch-and-release fishing (i.e. non-consumptive) or harvest-orientated fishing (i.e. consumptive) (Cooke et al. 2019; Yamazaki et al. 2011). However, beyond this dichotomy the motivations become complex and no longer mutually exclusive. These motivations include but are not limited to psychological and physiological benefits, spending time in natural environments, social engagements with others, a fishery/food resource, and engaging and overcoming skill and equipment challenges (Fedler & Ditton 1994). Although there is a plethora of research on fisher behaviour (Duttweiler 1976; Renyard & Hilborn 1986; Aas & Skurdal 1996; Teisl et al. 1993; Matlock et al. 1988; Fulton et al. 2011; Hoshino et al. 2017) the link between these motivations and responses to management are not always considered by fisheries scientists or managers (Fulton et al. 2011).

Given the diverse motivations and non-market nature of recreational fishing, evaluating fishers' preferences towards different management tools is non-trivial. Further complexity is added by the recent observation that it is unadvisable to reduce the preferences of heterogeneous fisher populations to homogenous ones which represents an average fisher (Matsumura et al. 2019). Two approaches that are commonly used to elicit the preferences of heterogenous recreational fisher population are (1) conducting a survey to obtain a self-reported measure of management preferences,

and (2) discrete choice experiments (DCEs). For example, previous survey studies have identified heterogeneous preferences of recreational fishers who are categorised by site (urban/ rural fishers) (Arlinghaus & Mehner 2004), locality (residents/ non-residents) (Teisl et al. 1993), water type (marine/ freshwater) (Frijlink & Lyle 2010), and avidity level (Mcllgorm et al. 2016). DCEs have also been used to categorise fishers' preferences across specialisation (Beardmore et al. 2013) and fishing method (Aas et al. 2000). A major difference between the two approaches is that surveys directly ask fishers to self-report their perceptions of each management tool in question, while DCEs force respondents to consider different management tools and account for trade-offs between them. The dual methodology may be advantageous as the use of both a survey and a DCE enables one to determine fishers' preferences and opinions on different management tools for comparable samples of fishers; however, such an application is limited in the literature.

The aim of this chapter is to evaluate recreational fishers' preferences of different management tools for a highly consumptive multi-method fishery. Specifically, we explore the potential heterogeneity in preferences among fishers with different avidity levels and fishing methods. We further examine whether, and to what extent, fishers are willing to accept trade-offs between changes in different management tools. We use the variation in avidity and fishing methods as a driver of heterogeneity in preferences as they are indicative of motivations and attitudes of recreational fishers. For example, avidity has been linked to centrality to fishing lifestyle (Mcllgorm et al. 2016). While avidity can be measured in different ways, such as commitment to the activity (i.e. willingness to substitute for another activity) or investment in fishing (Ditton & Sutton 2004), we measure avidity by the number of fishing days per season. We used fishing method as a proxy for fishers' differing in motivations or attitudes as (Lyle 2018) found that mode of fishing in the Tasmanian Rock Lobster fishery is correlated with fishers' behaviour in terms of harvest and effort.

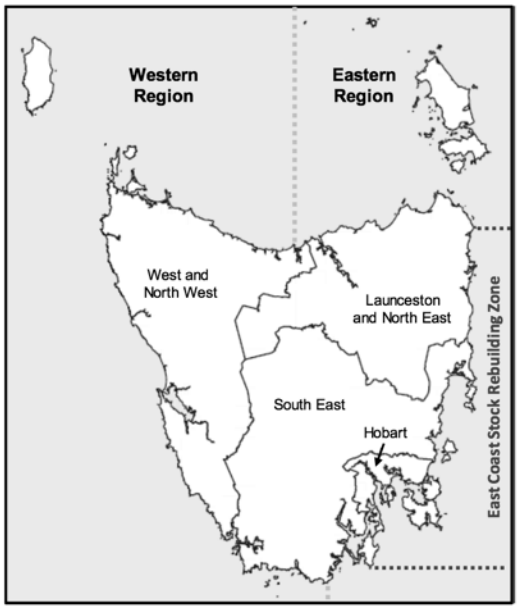
To achieve the research aims, we conducted a phone survey and a DCE for the current license holders in the Tasmanian east-coast recreational Rock Lobster fishery. The phone survey was used to ask fishers' opinions on how effective different management tools are at restricting catch and if they are supportive or opposed to the tool. Additionally, the DCE was used to assess if fishers' utility is associated with a management tool and to what extent fishers are willing to trade-off a change in one management tool for a change in another tool. The fishery has extensive management in place, such as separate fishing licenses required for different fishing methods, bag limits, and seasonal closures, with expected further management to be implemented in the near future. Therefore, management changes are not solely a hypothetical scenario. In the Tasmanian east-coast recreational Rock Lobster fishery, the stocks have been in decline and consequently a ten-year strategy was implemented in 2013 to rebuild them to healthy levels. To achieve this, measures to limit the amount of lobsters

caught were implemented for the recreational sector, but it was later found that further restrictions are required to meet and sustain the stock rebuilding goals (See Box 5.1 for more details). As a diverse fishery, with divers, potters, ring, and multi-use fishers present, as well as broad avidity levels, there is an urgent need to identify fishers' preferences towards different management tools and which groups of fishers would be most affected by management changes.

Box 5.1. Case study fishery

Jasus edwardsii, Male, Maria Island, Tasmania. Photo: Antonia Cooper. Reeflifesurvey.com

The Southern Rock Lobster (*Jasus edwardsii*) is highly prized within Tasmania, Australia, by both recreational and commercial fishers. During 2017-18 season (November 2017- April 2018) 17,200 people held at least one recreational Rock Lobster licence (Lyle 2018). They are fished using pots, ring nets and dive collection and annual licenses are required to use each of these methods to fish recreationally. During 2017-18 season, licensed recreational fishers were estimated to have harvested roughly 72,000 lobster, based on 77,209 fisher days of effort, with potting being the dominant fishing method used. The Rock Lobster fishery was concentrated off the east coast of Tasmania with this area accounting for 70% of the harvest (Lyle 2018). There are daily bag limits, boat limits, and possession limits in place as well as size limits, closed seasons and a total ban on taking females carrying eggs (Lyle 2018).



In the 2005 management review of the Tasmanian Rock Lobster fishery, provision was made for an explicit catch allocation to the recreational sector. More recent concerns over the status of the east coast Rock Lobster stocks resulted in the implementation a 10-year plan (2013-2023) to rebuild east coast stocks to greater than 20% of unfished biomass (DPIPWE 2018). The rebuilding strategy seeks to limit the total Rock Lobster catch from the east coast to 200 tonnes and is based on a notional resource sharing arrangement of 21% for the recreational sector (42 tonnes) and 79% for the commercial sector (158 tonnes). Key elements of the rebuilding strategy relevant to recreational fishers involved dividing Tasmania into Eastern and Western Rock Lobster Fishing Regions (Fig. 5.1), reducing Eastern Region bag and possession limits and delaying the opening of the Eastern region fishery. Given a positive correlation between recreational participation and catch (Lyle 2018), the number of licence holders is expected to increase along with an increase in the stocks in response to the stock rebuilding efforts. As there is currently no limit on the number of recreational licence holders, further restrictions on catch or effort are likely required to curtail increasing pressures on the stock.

Figure 5 1 Map showing Tasmanian Australian Statistical Geography Standard Statistical Areas Rock Lobster Fishing Regions and the current (2019) east coast stock rebuilding zone. Map taken from (Lyle 2018).

5.2 Methods

5.2.1 Discrete choice experiment

5.2.1.1 Conceptual framework

Discrete Choice experiments (DCE) are a survey-based stated preference approach that can elicit respondents' preferences for a good in question, such as preferences for different management tools. DCE evolved from Lancaster's (1966) theory of consumer behaviour, in which the utility derived from an alternative is associated with the attributes of the alternative. In DCE, the utility of alternatives is characterised based on the assumption that respondents choose the alternative that provides the greatest utility for them (Adamowicz et al. 1998). Specifically, our analysis relies on a random utility model, in which U_{nsj} denotes the utility of alternative j chosen by respondent n in choice situation s. The utility U_{nsj} has two separate components: i) an observable component of the utility, V_{nsj}; and ii) unobservable component, ε_{nsj}, such that:

$$U_{nsj} = V_{nsj} + \varepsilon_{nsj} \quad (1)$$

The observable component of the utility, V_{nsj}, is expressed in terms of a linear combination of k attributes, such that:

$$U_{nsj} = \beta X_{nsj} + \varepsilon_{nsj} \quad (2)$$

where X_{nsj} is a vector of k observed attributes for the good in question and β is a vector of the corresponding parameters (i.e., marginal utilities). In choice situation s, respondent n will choose alternative j if $U_{nsj} > U_{nsi}$ for all $j \neq i$. Assuming a Type I extreme value distribution for the unobservable component, ε_{nsj}, the probability that respondent n chooses alternative j in choice situation in s is given by (Mcfadden 1981):

$$\text{Prob}\left(y_{it} = j\right) = \frac{\exp\left(\beta X_{nsj}\right)}{\sum_{s=1}^{S} \exp\left(\beta X_{nsj}\right)} \quad (3)$$

Equation (3) provides a basis to model the choices made by respondents in DCE as a function of the attributes. That is, discrete choice data is used to determine the attributes, which are significantly associated with respondents' utility, and the extent to which respondents are willing to trade one attribute for another or rather opt-out. Although a number of challenges have been identified (Carson 2012; Hausman 2012), the usefulness of DCE to support policy-making has been widely acknowledged (Hussain et al. 2014; Rogers et al. 2015; Marre et al. 2016). The main advantage of DCE over a self-reported survey is that survey respondents are placed in a choice situation requiring them to consider trade-offs between attributes and to choose the alternative that provides the greatest utility.

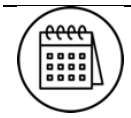
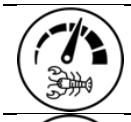
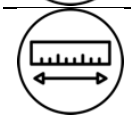
5.2.1.2 Discrete choice experiment design

Alternatives in a choice task are defined by a set of attributes and their levels. Table 5.1 provides the description of each attribute and associated levels used in this chapter. We based attribute and level selection on a number of sources, including: i) an discussion paper summarising management options to restrain Rock Lobster catches (DPIPWE, unpublished data.); ii) results from previous recreational Rock Lobster surveys (Lyle and Tracey, 2016; Lyle and Tracey, 2017; Lyle, 2018); and iii) extensive discussions with fishery experts. Since the objective of the chapter is to examine management preferences and the fishery is predominantly a consumptive fishery, attributes around the fishing experience were not included.

To determine the number of attributes and the levels, we first identified management restrictions which are already in place or have been discussed to be used in future management. We then selected five restrictions as management attributes, which are considered as the most effective at reducing catch in this fishery and having clear links to recreational fishing experience. The attributes included in the DCE are: (1) Daily Bag Limit, (2) Season length, (3) Maximum seasonal catch limit per person, (4) Minimum size limit for female Rock Lobster and (5) Penalties for non-compliant acts (Table 5.1).

The daily bag limit at the time of chapter was two lobster. The bag limit had been reduced from five to three in November 2011 and then to two lobster per day in November 2015. Therefore, we considered a further restriction to one, as well as renewing the bag limit to three as the levels of this attribute. The levels for the season length and maximum seasonal catch limit were set based on the current season length (24 weeks) and the average ranges of seasonal catch and frequency of fishing events found in previous surveys (Lyle and Tracey, 2016; Lyle and Tracey, 2017; Lyle, 2018). An increase in the minimum size limit for females is another restriction that has been proposed as a measure to assist with stock rebuilding by providing additional protection to the adult (female) stock and enhance egg production. We set the levels of this attribute relative in scale to size increases that would provide at least a year of additional protection to breeding females. Finally, for attribute (5), we were non-specific with the non-status quo level and alternative since a penalty for a non-compliant act can take many forms. All attributes, except attribute (3), are already in place in this fishery – with the status quo representing the current management. There is currently no limit on the maximum number of lobsters one licensed fisher can catch in a season, however, implementing such a restriction has been discussed with resource managers and stakeholders as a potential tool to reduce the overall recreational catch.

Table 5 1 Attributes and levels used in discrete choice experiment

Attribute		Description	Levels					
			Status Quo 0	**1**	**2**	**3**	**4**	**5**
	1. Daily bag limit	The number of Rock Lobster that any licensed fisher can legally retain per day	2/ day	1/ day	3 / day			
	2. Season length	The number of weeks the fishing season is open	As for 2018 (24 weeks)	16 weeks	8 weeks			
	3. Maximum seasonal catch	Maximum number of one licenced fisher can keep over the entire season	No limit	8	12	16	20	24
	4. Minimum size limit for females	Minimum legal size limit for female Rock Lobster	As is (105mm)	Increase by 5 mm	Increase by 10 mm			
	5. Penalties for non-compliant act	The penalty given for non-compliant acts	As is	Increase by 50%				

In total, there are 324 combinations for the five attributes and associated levels in Table 1. It is not feasible to ask respondents to select their choice from the universe of all possible combinations. Relevant combinations of attribute levels can be generated in multiple ways, such as orthogonal designs (Louviere et al. 2000) or efficient designs (Rose & Bliemer 2009). In this chapter, an efficient design was used to avoid unrealistic scenarios in the management context of this fishery. Using *a priori* expectations of the parameter estimates, efficient designs can also improve the reliability of the estimated parameters (i.e., standard errors) for a given sample size (Huber & Zwerina 1996). The utility for each attribute was modelled using Ngene (ChoiceMetrics), which produced 18 choice sets (i.e., scenarios) with balanced utility, as per the efficient design. While it is possible for respondents to answer all choice sets, it is common to divide the choice sets into blocks to make the DCE quicker to complete and reduce participant fatigue. In this chapter, we had three blocks of six choice sets. To minimise any ordering effect, we randomised the order of each of the blocks into five orders. The order and block of the choice sets were randomly allocated per respondent.

For each choice set, respondents were asked to compare the options and decide which option they would choose to renew their licence for or whether they would choose not to renew their licence (Fig 5.2). Following the choice task, respondents were asked to complete a self-assessment on the understanding and confidence in completing the DCE. Respondents who opted out for every choice

set were removed from the analysis as these were considered protest votes (n=6), and those who answered 'not certain at all' to conducting the DCE were also removed (n=7). In addition to the choice sets, we collected data on fishers' participation, fishing methods, demographics, and motivation and attitudes towards compliance management in the same survey.

Scenario 1 (out of 6)

Please compare the following three options for the management of the Rock Lobster recreational fishery in the eastern region of Tasmania. Assuming these are the only options available to you, which of the options do you prefer?

You should base your preferences considering your actual fishing experiences, for instance consider these options in relation to how often you go (or would hope to go) fishing/diving for lobster, your usual catch rates and the sizes of the lobsters you normally catch.

Management feature	Option A	Option B	Option C
Daily bag limit	2/ day	2/ day	I wouldn't renew my licence
Season length	8 weeks	16 weeks	
Maximum seasonal catch limit per licence holder	12 lobsters/ season	8 lobsters/ season	
Size limit for females	Increase by 10mm	As is	
Penalties for non-compliant acts	As is	Increase by 50%	

A1a) Which of these options do you prefer? (Please tick)

Option A_____ Option B _____ Option C _____

A1b) If you chose Option C above, from the remaining two options, which do you prefer? (Please tick)

Option A_____ Option B _____

Figure 5 2. Example choice set given to fishers

5.2.1.3 Data analysis

Discrete choice data from the DCE were modelled by a conditional logit model which estimates the marginal utility associated with each attribute; i.e., β in Equation (3). Estimates of the marginal utility were then used to assess if and to what extent respondents are willing to trade one management attribute for another while maintaining the same level of utility. For this, the marginal rate of substitution between two attributes provides an estimate of the relative importance of one attribute compared to the other. Specifically, we calculated the ratio of marginal utilities of attributes (2)-(5), relative to reduction of bag limit by one lobster. For example, the ratio $\beta_{season\ length}/\beta_{bag\ limit}$ represents, if the bag limit was reduced by one, how long the season length would have to increase to account for the utility loss. To examine heterogeneity in preferences, we first estimated the model for the entire

sample, and then for the sub-sample of fishers who used different methods and those who had different avidity levels.

5.2.2 Phone survey design

Previous phone surveys of the recreational Rock Lobster fishery have been conducted since the mid-1990s and provide detailed information about the fishing activity of individual survey respondents, including the date, location, method, and catch for each day fished for Rock Lobster. The survey instrument used here is based on that used successfully in previous recreational fishing surveys in Tasmania (Lyle, Stark and Tracey, 2014; Lyle and Tracey, 2016; Lyle and Tracey, 2016; Lyle and Tracey, 2017; Lyle, 2018) and independently reviewed by Pollock (2010).

The phone survey asked about fishers' opinions regarding a range of management options. The specific questions related to the research questions for this chapter, asked fishers their opinions on how effective six management tools were at restricting catch as well as if they were generally supportive or opposed to the tool (3-point Likert scale). The six management tools were; bag limit, season length, maximum seasonal catch, size limit, limiting the number of licences, and reducing the commercial catch allowance (see Table 5.2 for exact wording of questions).

5.2.3 Sampling framework

The survey sample was selected from the 2017-18 recreational licensing database administered by the Department of Primary Industries, Parks, Water, and Environment. The data collection was conducted in two steps. First, a random sample of recreational Rock Lobster licence holders for the 2017-18 fishing season were contacted by telephone and asked to complete the phone survey. Of 729 fishers contacted, 570 agreed and completed the survey between May and June 2018. Second, fishers were recruited from the phone survey to complete the DCE. Only those who resided or predominantly fished in the east coast region were asked to conduct the DCE. Of the 570 fishers who completed the phone survey and who resided or fished in the east coast region, 307 fishers agreed to do the DCE either via mail or an online platform (104 requested mail surveys and 203 requested online surveys). The online and mail surveys were conducted between May to October 2018 and 156 completed DCEs were received (51 mail and 105 online).

5.3 Results

5.3.1 Distribution of fishing methods and avidity

For fishers who participated in the phone survey, potting (either by itself or in combination with ring nets) was the most common fishing method used (51%). Multi-use (a combination of diving and potting or ring nets) was the second largest group (35%) and diving was the least common group (14%). The distribution was analogous between the fishers surveyed in the phone survey and the DCE (Fig. 5.3a). 50% of fishers who participated in the DCE used only pots or pots and ring nets, 13% of fishers dived for lobster and 36% of fishers used a combination of these methods. The distribution is consistent with the distribution found in previous recreational Rock Lobster surveys (Lyle 2018).

The distribution of avidity of fishers (i.e., reported number of fishing days per season) differed between the phone survey and the DCE (Fig.5.3b). The phone survey sample comprised of 60% low avid fishers (10 days per season or below), 29% mid avid fishers (11-25 days per season), and 11% high avid fishers (over 25 days per season). In contrast, the DCE sample consisted of only 42% low avid fishers, 32% mid avid fishers but 26% high avid fishers. The skew in avidity between the surveys –with high avid fishers representing more of the sample for the DCE - is likely because high avid fishers are more willing to take part in surveys related to fishing than low avid fishers. The correlation between fishing method and avidity was low for both surveys (r = -0.1 for phone survey and r = 0.07 for DCE), suggesting that heterogeneity in management preferences in the two categorisations of fishers may be different to each other.

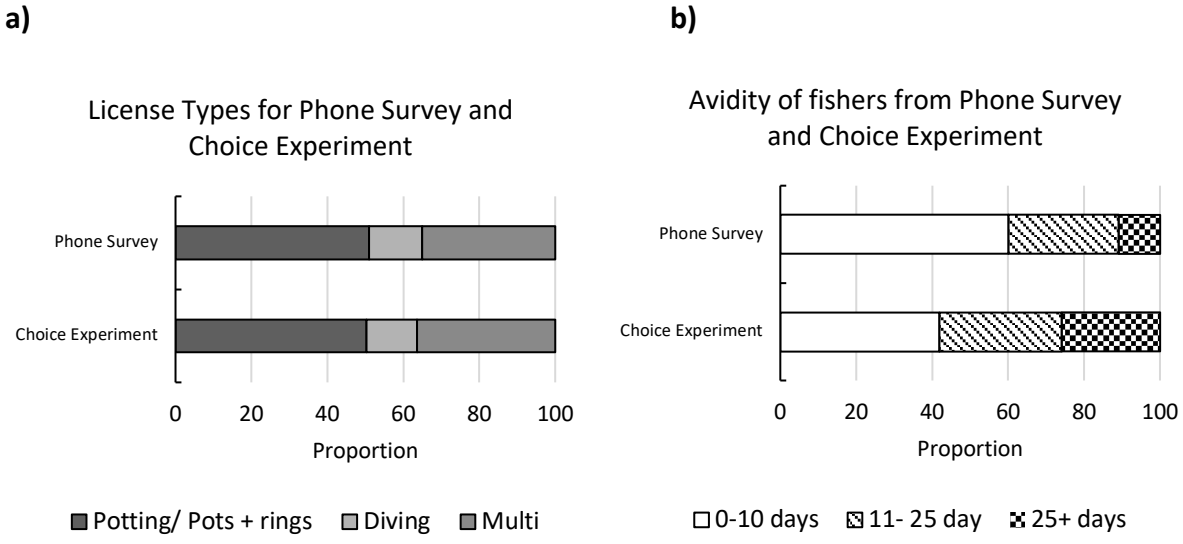


Figure 5 3. Distribution of a) fishing method by license type and b) avidity of the fishers who took part in the phone survey and the choice experiment.

5.3.2 Phone survey management preferences

Support varies across the management tools but is generally medium to high support (> 28%) except for limiting licence numbers (Table 5.2). The most strongly supported and perceived effective management tool for all fishers was a maximum seasonal catch. 75.7% of fishers thought it was an effective tool and 73.9% of fishers attested they would support it. When asked "How many lobsters would you consider as acceptable for such a seasonal catch limit?" as a follow up question, the responses ranged from 2-300 lobster per fisher per season. The median was 20 lobster per fisher per season (mean 25.9), while 16% of fishers recommended limits of 40 or more and 2% recommended limits of 100 or more lobster. The least supported and perceived effective management tool for all fishers was a limit on the number of licences. 77.6% of fishers thought it was not an effective tool and 85.3% indicated they would not support it.

There is a small proportion of fishers who were unsure about the effectiveness or if they would support any of the management tools (ranging 2%-10% across different management tools). The lowest proportion of unsure responses was for a reduction in daily bag limit, suggesting high certainty of opinion, whereas 10% of fishers were unsure for a reduction of commercial catch allowance, suggesting low certainty of opinion around this management tool. There is a strong positive correlation between supporting the management tool and perceived effectiveness (last column Table 5.2). This suggests that if a management tool is perceived to be effective then it is generally supported (or vice versa if it is supported then it is perceived to be effective).

Table 5.2 Fishers' opinion on effectiveness and support to management tools

Management tool	Response	Effective		Support		Support effectiveness correlation (r)
		No.	%	No.	%	
Reduce the daily bag limit to one per day	Yes	204	40.6	143	28.7	0.792
	No/ Not really	288	57.4	344	68.9	
	Unsure	10	2.0	12	2.4	
Further reduce the length of the season (in the eastern region)	Yes	272	54.3	244	48.9	0.870
	No/ Not really	205	40.9	235	47.1	
	Unsure	24	4.8	20	4.0	
Introduce a maximum east-coast seasonal catch limit for each licence holder	Yes	380	75.7	369	73.9	0.885
	No/ Not really	107	21.3	114	22.8	
	Unsure	15	3.0	16	3.2	
Increase the minimum size limit, meaning more of the catch is released	Yes	306	60.8	274	54.8	0.848
	No/ Not really	170	33.8	204	40.8	
	Unsure	27	5.4	22	4.4	
Limit the number of licences that have access to the eastern region for lobster	Yes	83	16.6	45	9.0	0.899
	No/ Not really	388	77.6	425	85.3	
	Unsure	29	5.8	28	5.6	
Reduce the commercial catch allowance to offset any increase in recreational catches	Yes	291	58.1	266	54.6	0.881
	No/ Not really	160	31.9	175	35.9	
	Unsure	50	10.0	46	9.4	

We detect heterogeneity in support once we compare fishing methods and avidity levels (Fig. 5.4). Divers are the most supportive fishers for all management tools, except the introduction of a seasonal catch limit. A reduction of bag limit has significantly lower support from potters and multi-use fishers than for divers ($\chi2 = 15.20$, df= 2, $p = 0.0005$). Likewise, an increase in size limit has more support from divers compared to potters and multi-use fishers ($\chi2 = 6.75$, df=2, $p = 0.034$). There were no significant differences for the other management tools for fishing method. When categorised by avidity level, we observe that less avid fishers were generally more supportive of management tools. However, only a reduction of season length was significantly different for the levels of avidity ($\chi2 = 7.64$, df=2, $p = 0.02194$).

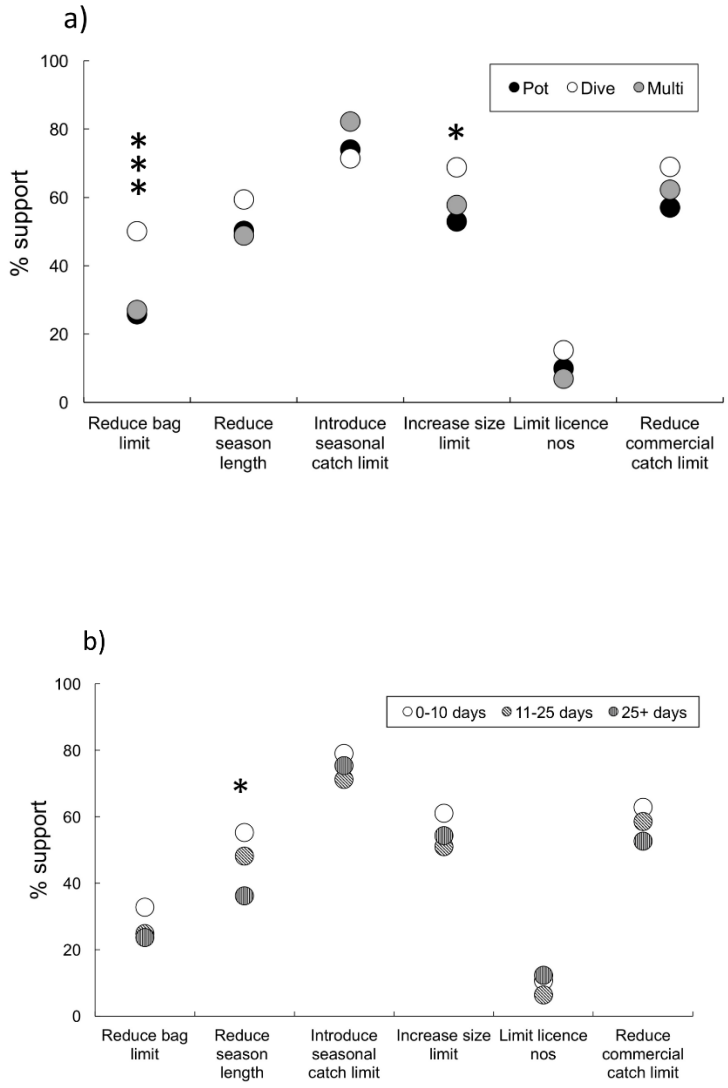


Figure 5.4 The proportion of fishers who support each management tool for a) different fishing methods and b) different levels of avidity determined by the number of fishing days per season. Unsure and NA responses were removed. Significant difference between groups from chi squared test of independence indicated by the asterisks, (p-values: <0.001 =***, <0.01= **, <0.05 = *, <0.1 = .)

5.3.3 Discrete choice experiment management preferences

The results of the choice experiment for the full sample of fishers showed that all management tools have positive coefficients, and this is expected as fishers on average prefer less regulation (Fig. 5.5). However, only a bag limit and season length were significant at the 5% level and introducing a maximum season length was significant at the 10% level. An increased size limit for females and increased penalties were not significant for the whole sample.

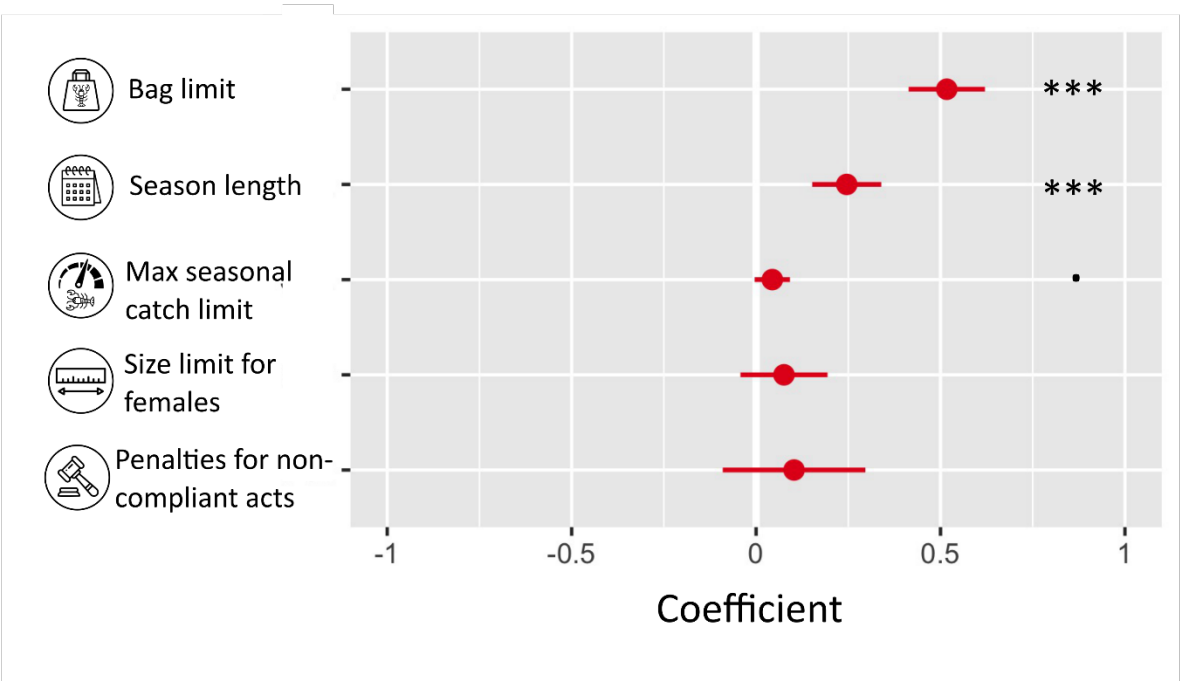


Figure 5 5. Conditional logit model results of the choice experiment responses for all fishers. Error bars indicate standard error (p-values: <0.001 =***, <0.01= **, <0.05 = *, <0.1 = .) See Appendix 5 Tables 5A.1 and 5A.2 for detailed regression results.

When the model was estimated for the subsample of each fishing method, bag limit had a significant coefficient for all fishing methods (Fig. 5.6a), meaning that there is no heterogeneity in preferences towards the bag limit. The regression, however, shows heterogeneous preferences for season length and maximum seasonal catch limit. The coefficient for season length was significant and positive – indicating preference for an increase in season length- for potters and multi-use fishers, but not significant for divers. Likewise, the coefficient for maximum seasonal catch was significant for divers and potters only indicating preference for a higher maximum seasonal catch (the latter only at the 10% level). All other management tools; increase in size limit and increase in penalties were not significant for all fishing methods.

Across all levels of avidity, bag limit and an increase in season length were the management tools which have a significantly positive coefficient (Fig 5.6b). A maximum seasonal catch limit was significant for low avid fishers only. An increase in size limits for females was only significant for high avid fishers while an increase in penalties was not significant for all fishers.

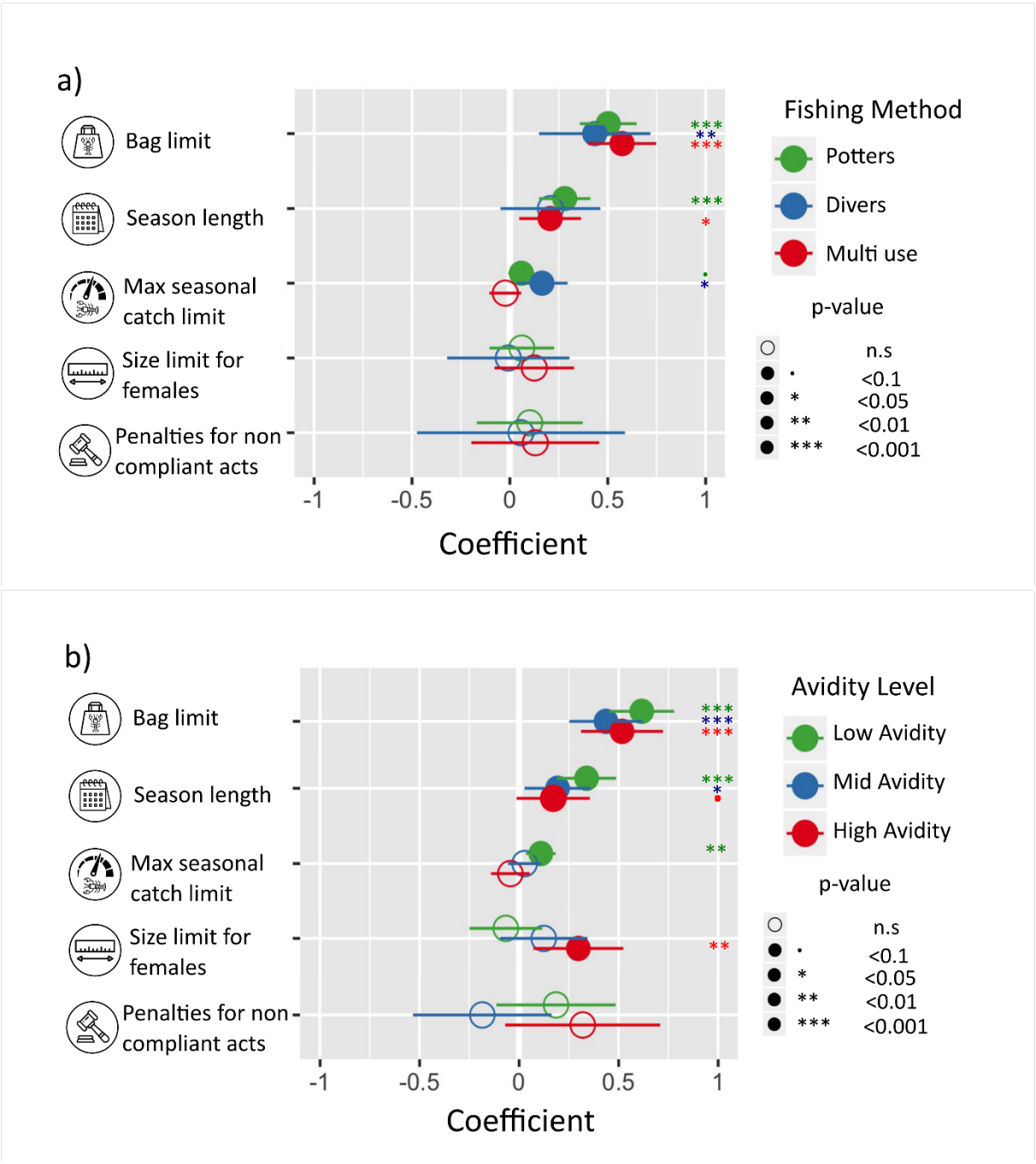


Figure 5.6. Conditional logit model results of the choice experiment responses for a) each fishing method and b) each avidity level. Error bars indicate standard error (p-values: <0.001 =***, <0.01= **, <0.05 = *, <0.1 = .) See Appendix 5 Tables 5A.1 and 5A.2 for the detailed regression results.

5.3.4 Management trade-offs

The trade-offs fishers are willing to make for a reduction of bag limit by one lobster is reported in Figure 7. The results are presented for the full sample of fishers, as well as for the subsample of each group determined by fishing method and avidity level. Fishers are on average willing to accept a decrease in the bag limit by one lobster if the season length increases by 3.5 weeks (Fig. 7a) This trade-off ranges from the highest for potters (4.5 weeks) and low avid fishers (4.4 weeks) to the lowest for

multi-use fishers (2.9 weeks) and high avid fishers (2.6 weeks). This result suggests that the value of season length is felt by most fishers but is relatively higher for potters and low avid fishers.

The variability across different groups of fishers in the trade-off for season length is less compared to the other management tools. The trade-off for a maximum seasonal catch is highly variable across groups (Fig. 7b). The highest trade-off is for divers at 1.5 lobsters per season, indicating that divers would be most affected by the introduction of the maximum seasonal catch limit. For size limit for females, the trade-off is highest for high avid fishers who are willing to accept a decrease in the bag limit by one lobster if the size limit for females decreases by 2.9 cm. Finally, the trade-off for penalties is relatively consistent across groups, except for mid and high avid fishers.

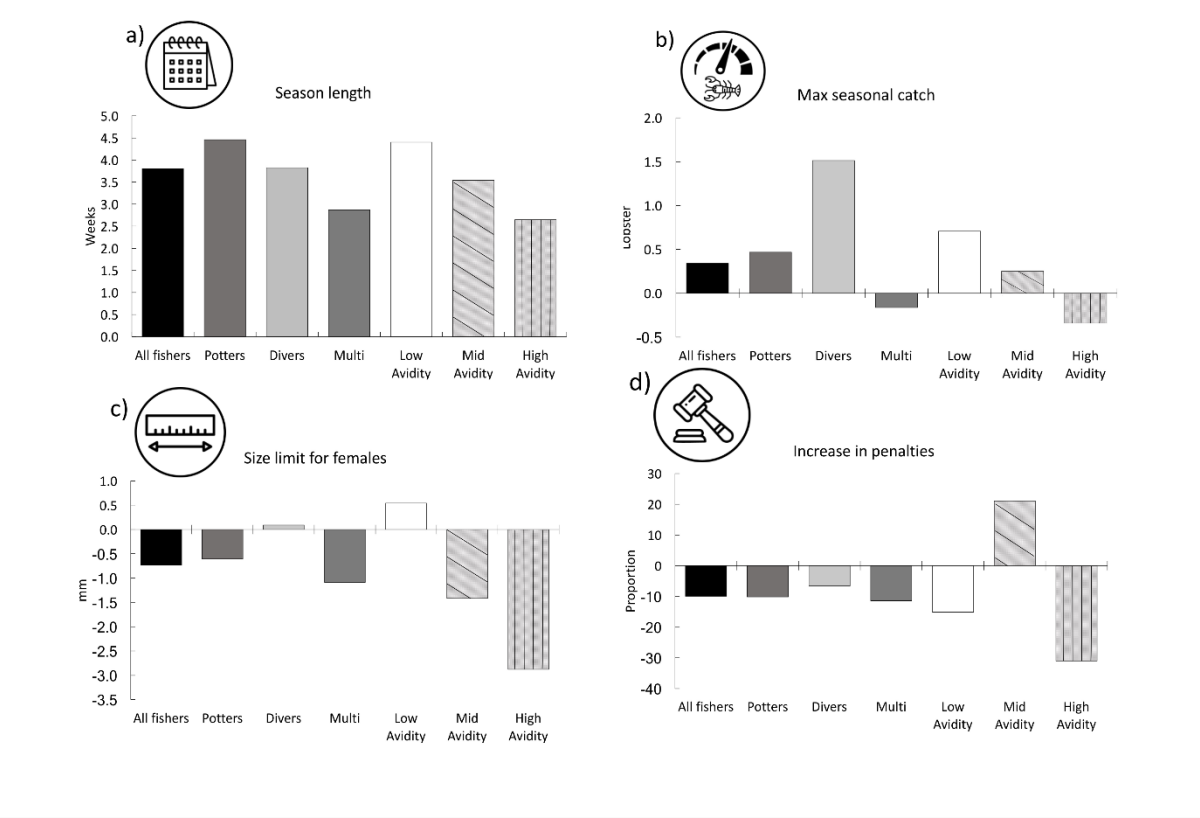


Figure 5.7 Trade-offs fishers are willing to make between a reduction in bag limit by one lobster and a change in a) season length, b) maximum seasonal catch, c) minimum size limit for females and d) penalties for non-compliant acts.

5.4 Discussion

To account for behavioural responses to the management of recreational fisheries, it is important to improve our understanding of fishers' preferences towards different management tools. To this end, we conducted a phone survey and a discrete choice experiment in the Rock Lobster fishery in the east coast of Tasmania as a case study of a highly consumptive recreational fishery with diverse fisher groups. Acknowledging the links between avidity and fishing methods as proxies for motivations and behaviours in this fishery (Lyle 2018), we focussed on these two categorisations of fishers to evaluate recreational fishers' preferences of different management tools, which are either already in place or have been discussed to be used in future management to reduce catch and assist in stock rebuilding goals in the fishery.

Overall our results show that preferences for some management tools are homogenous across fishers that differ in avidity and divergent fishing methods, while preferences for other tools are heterogenous. There was consensual aversion towards a reduction in daily bag limit for all fishers. This was evident from low perceived effectiveness and support as well as that a reduction in daily bag limit significantly decreases fishers' utility for all groups. This was anticipated as it is a highly consumptive harvest-oriented fishery. A reduction in season length was another management tool that was found to impact most fishers' utility, except divers and high avid fishers. In the phone survey, however, highly avid fishers indicated the lowest support for a reduction in season length and the trade-off between season length and daily bag limit had little variability across groups indicating a homogenous preference toward season length. In contrast to these management tools, we found heterogeneous preferences for an introduced maximum seasonal catch and an increase in minimum size limit for females. These results may reflect the fact that the management tools in which there was heterogeneity in preferences limit catch indirectly. A reduction in bag limit and shortened season, however, have direct and clear implications on expected catch and recreation time. There was clear consensus among fishers about these management tools, whereas a change in size limit or an introduced maximum seasonal catch require some individual reflection on their historical and expected catch rates and sizes.

Among fishers who use different fishing methods, the phone survey results suggest that divers were generally the most supportive group for further management. However, the DCE shows that these fishers would be the most impacted if a maximum seasonal catch was implemented. This was indicated by the largest trade-off required in the maximum seasonal catch. This is expected as divers had the largest average daily harvest rates in 2017/18 compared to the other fishing methods (average

1.59 lobster per day fished for dive collection compared to 1.38 for rings and 0.73 for pots) (Lyle 2018). However, our results also suggest that most fishers will be affected if a maximum seasonal catch limit is implemented to meet the stock rebuilding goals. Given the number of recreational fishers in the 2017/2018 season, the maximum season catch needs to be set at ~ 4 lobster per fisher to meet the 42-tonne total allowable recreational catch for the east coast region of Tasmania. This is considerably lower than the mean or median acceptable number of lobsters per season (25.9 and 20, respectively) perceived by fishers.

Recreational fishing specialization, which is defined as a spectrum from "general interest and low involvement to specialized interest and high involvement" (Bryan, 1977: 175) is correlated with avidity (Han & Oh 2018). Our survey results found low avid fishers were generally most supportive for all management tools in the phone survey, except limiting the number of licences. This coincides with the findings in Salz & Loomis (2005), in which low specialized fishers were more supportive for regulations and acknowledged the detrimental impacts recreational fishing has on fish stock more than high avid fishers do. In our DCE results, compared to the other avidity levels low avid fishers had a larger trade-off for an introduced seasonal catch limit, even though such a limit is less likely to constrain their behaviour. Theory of specialisation in fisheries suggests that high avid fishers would be more accepting of further regulations (Bryan 1977). Our results were contrary to this for size limit for females and an increase in penalties as from the results suggest high avid fishers would be impacted by an increase in size limit for females and would dislike an increase in penalties for non-compliant acts.

There are some caveats that should be considered when our results are interpreted and applied to other recreational fisheries. First, there may have been strategic bias in the phone survey in which fishers were asked to express their opinions about each management tool independently. Although the survey was conducted with no reference to government involvement, fishers may have not revealed true beliefs due to the sensitivity of the topic. For example, fishers may have indicated that a tool was not effective or not having support as they would not want this tool to be implemented; e.g., low support and perceived effectiveness for bag limit reduction. The joint use of an opinion-based measure of management preferences and DCE analysis may help to identity such potential bias as DCEs force survey participants to consider trade-offs between different management tools. Second, there was a skewed representation of high avid fishers in the DCE data. This is consistent with other literature, where a self-nominated survey represents a sub-population of more avid fishers (McIlgorm et al. 2016). Although our results from the phone survey and DCE are consistent with each other, the

more significant preference heterogeneity across different avidity levels identified in the DCE analysis is possibly due to the higher representation of high avid fishers in the data. Lastly, we categorised fishers prior to the data analysis using fishing methods and avidity as they are indicative of fishers' motivations and behaviour in our case study (Lyle 2018). However, in fisheries where these relationships are not well established, a prior categorisation of fishers is not possible. An alternative way to deal with potential heterogeneity in preferences is to use mixed logit or latent class models. While the details of these models are provided in (Hensher et al. 2005), both models assume that individual preferences for each attribute are not fixed within the sample but are drawn from a probability distribution (mixed logit model) or can be categorised into group preferences (latent class models).

5.5 Conclusion

We set out to understand the uncertainty in fishers' preferences across different fishing methods and avidity levels. We found that there is some certainty in opinions and behaviours for management tools and this was related to how direct a management tool has on catch. The importance, application and, novelty of these results relates to the added insight for decision makers towards effective evidence-based decision making. Within this context, for example, it was clear that a reduction in bag limit or season length would be disruptive to all fishers. This may lead fishers leaving the fishery or non-compliant behaviour. Changes to the management tools that had more heterogeneity and less consistency in preference and utility, such as an increase in minimum size limit, may be better received as they do impact catch but indirectly. Considering the multiple objectives that are involved in fisheries management, the results provide the necessary understanding of preferences across the groups and for each management tool. Management tools that target indirect catch reduction may be a more successful tactic to fulfil restocking goals while minimising utility impact of fishers. Using an approach to evaluate preferences for inclusion in the decision-making process is highly advisable as decision makers can justify decisions on accordant preferences and weight up the trade-offs for divergent preferences. We expect future research to build on this understanding that fisheries may have homogenous and heterogeneous preferences and behaviours to then better assess and explain actions in catch, compliance, and participation that may have previously been amalgamated and generalised across the fishing population.

Acknowledgements

We would like to thank the recreational fishers for taking part in the phone and discrete choice experiment survey and Fiona Ewing for data management and logistics. Funding for this study was provided by the Australian Government through the Fisheries Research and Development Corporation and the Institute for Marine and Antarctic Studies, University of Tasmania. All data collection was carried out following the guidelines, and with the approval of, UTAS Human Research Ethics Committee (H0017285).

Chapter 5 Appendices

Appendix 5A : Conditional logit model results

Table 5A.1. Conditional logit model on discrete choice experiment data for different fishing methods

	All fishers	**Potters**	**Divers**	**Multi**
Bag limit	0.517	0.502	0.433	0.573
	(0.000)	(0.000)	(0.003)	(0.000)
Season length	0.246	0.280	0.207	0.205
	(0.000)	(0.000)	(0.111)	0.011
Maximum seasonal catch limit	0.044	0.059	0.164	-0.023
	(0.072)	(0.085)	(0.014)	(0.574)
Size limit for females	0.076	0.061	-0.008	0.125
	(0.209)	(0.468)	(0.961)	(0.229)
Penalties for non-compliant acts	0.103	0.102	0.057	0.131
	(0.297)	(0.460)	(0.833)	(0.433)
Constant	-1.979	-2.041	-2.045	-1.864
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	2,574	1,314	342	918
Number of subjects	143	72	19	52
Log-likelihood	-1459.7	-740.7	-193.7	-521.7
McFadden's pseudo-R2	0.109	0.114	0.110	0.107
AIC	2931.3	1493.5	399.39	1055.4

Note: This table reports the estimates of the coefficients and *p*-values in parentheses from different model specifications.

Table 5A.2. Conditional logit model on discrete choice experiment data for different avidity levels

	All fishers	**Low Avidity**	**Mid Avidity**	**High Avidity**
Bag limit	0.517	0.616	0.437	0.517
	(0.000)	(0.000)	(0.000)	(0.000)
Season length	0.246	0.339	0.193	0.171
	(0.000)	(0.000)	(0.023)	(0.068)
Maximum seasonal catch limit	0.044	0.109	0.027	-0.044
	(0.072)	(0.004)	(0.523)	(0.374)
Size limit for females	0.076	-0.067	0.124	0.298
	(0.209)	(0.475)	(0.270)	(0.010)
Penalties for non-compliant acts	0.103	0.186	-0.184	0.320
	(0.297)	(0.223)	(0.299)	(0.106)
Constant	-1.979	-2.395	-1.657	-1.877
	(0.000)	(0.000)	(0.000)	(0.000)
Number of observations	2,574	1,080	828	666
Number of subjects	143	60	46	37
Log-likelihood	-1459.7	-582.5	-486.7	-377.7
McFadden's pseudo-R2	0.109	0.153	0.077	0.109
AIC	2931.3	1176.9	985.34	767.43

Note: This table reports the estimates of the coefficients and *p*-values in parentheses from different model specifications.

Chapter 6- General Discussion

Minimising anthropogenic pressures on the ocean from recreational fisheries is complicated and relies on effective management and compliance. Encouraging sustainable recreational fisheries is difficult due to diverse motivations of recreational fishing and uncertainty in fishers' behavioural responses to management changes. Understanding the human dimensions of recreational fisheries management, particularly motivations, behaviours and preferences of recreational fishers, is therefore necessary for effective evidence-based policy making (Beardmore 2013). This thesis has contributed to this understanding: first, by conducting a literature review on alternative compliance tools, such as behavioural nudges, that can be used to encourage voluntary compliance in recreational fisheries; second, by empirically exploring the role of a descriptive social norm nudge on compliance behaviour using an economic experiment; third, by examining the association between of individual psycho-social characteristics and compliance behaviours; and, fourth, by measuring fishers' opinions and preferences of management tools to reduce catch in a consumptive recreational fishery.

This thesis took an interdisciplinary approach, drawing upon learnings from behavioural economics, nudge theory, compliance theory, and social psychology to explore the role of incentives on behaviours and preferences in recreational fisheries. In this chapter, I summarise the results of this research, and its contribution towards more effective understanding of recreational fisheries management and fishers' behaviours. I go on to outline further research that is needed to develop a better understanding of the potential roles of incentives on behaviour and preferences in recreational fisheries.

The thesis sets out firstly to explore the potential for alternative compliance tools to bolster traditional deterrence methods within recreational fisheries management. Chapter 2 explores the potential of nudges through a narrative review of the relevant literature with specific reference to the compliance of fishers within Australian recreational fisheries. Based on their theoretical foundations, nudges may present an inexpensive, and potentially highly effective opportunity for recreational fisheries management. There are examples of nudges in place in Australia using simplification and framing techniques and changes to the physical environment to encourage compliance with size limits. Chapter 2 also highlighted several concerns and consequences when nudges are applied as a compliance management tool. There are, for example, concerns around the ethics of nudging using false information or using manipulative tactics. Nudges need to be properly considered as to avoid any confusion or unintended consequences such as unintended compensating behaviours. For example, in a recreational fishery in which a nudge improves compliance with spatial closures but results in an increase in pressure outside the closed areas, with overall negative ecosystem outcomes.

Failure to account for these effects may unintentionally decrease ecosystem health or overall compliance. A 'one nudge fits all' approach to improving compliance is unlikely to work effectively and that multiple or different nudges will be needed. This chapter concludes in stating the importance for testing potential compliance nudges in a systematic and controlled manner and through careful design nudges have the potential to contribute to improved recreational compliance, thereby avoiding the threats that non-compliance poses to marine systems, locally and globally.

The next two chapters (Chapters 3 and 4) focussed on empirical work and used an economic experiment to test a nudge/ normative compliance incentive intended to encourage voluntary compliance behaviour in a recreational fisheries context. The aim of Chapter 3 was to quantitatively evaluate how a nudge based on a descriptive social norm can influence compliance behaviour in a static common pool resource (CPR) game. Descriptive social norms – i.e. a message reflecting what is common practice among peers- have been found to be an effective factor among instrumental and psycho-social drivers at predicting compliance behaviour. Our CPR game has been further adjusted to better capture the recreational fishing context by using a specification of the payoff function that reflects two types of benefits, a direct use value associated with catching fish, as well as a benefit derived from the experience itself. The results of the economic experiment provide evidence that a descriptive social norm nudge and traditional deterrence may act as substitutes, suggesting that nudges may be a more cost-effective compliance tool than deterrence-based approaches when the total costs of enforcement are taken into consideration. We also found that the nudge was more effective when deterrence is low, but its effects become weaker when deterrence is already high. The experimental design also permitted to uncover the extent of heterogeneity in individuals' response to a nudge and increase in deterrence, with evidence of ineffective and unintended responses by some individuals. For example, there are those who remained non-compliant or even increased catch in response to compliance measures. Overall, the results validate the effectiveness of a descriptive social norm nudge in delivering positive outcomes for recreational fishing compliance especially in contexts where existing deterrence mechanisms are initially weak.

Subsequently, Chapter 4 investigated if there is any association between psycho-social characteristics and responses to compliance incentives. Accurately understanding the different responses to instrumental and normative incentives and highlighting the psycho-social patterns within these responses is highly relevant for fisheries policy. In this chapter, we first identified patterns in compliance behaviour. The pattern reveals a group of people who are consistently compliant, a group who are consistently non-compliant, a group who respond counterintuitively, and a group who are

incentivized to become compliant (as intended by the management incentive). In this chapter, we further explored how the pattern in compliance behaviour is associated with five psycho-social factors, three of which (perceptions of behaviour of others, social norms, and risk preferences) have separately been explored within the fisheries compliance literature, while two factors (ecological values and personality types) had yet to be explored. While information about these two latter characteristics is limited within the fisheries compliance literature, our results suggest that they are relevant predictors for different compliance groups across compliance incentives. The findings underline that there is significant heterogeneity in the associations between psycho-social make-up and compliance behaviours. Knowledge of this behavioural relationship can progress fisheries management towards increased innovation by encouraging the management of the individual fisher rather than the average fisher.

Finally, the thesis explored the fishers' management preferences towards different management tools in a highly consumptive recreational fishery. Chapter 5 used a combination of a discrete choice experiment and an opinion-based survey to explore the potential heterogeneity in management preferences in the Tasmanian recreational Rock Lobster fishery, Australia. This fishery has extensive management in place, yet further restrictions are required to limit the amount of lobster caught for the recreational sector due to declining stocks. This chapter uses the variation in avidity and fishing methods as a driver of heterogeneity in preferences as they are indicative of motivations and attitudes of recreational fishers. There are, however, difficulties in fulfilling stock rebuilding goals without impacting fishers' utility if management becomes stricter. This chapter highlights that that is true when it comes to management tools that directly impact catch, such as bag limits and season length. This was anticipated as it is a highly consumptive harvest-oriented fishery. In contrast to these management tools, there were heterogeneous preferences for an introduced maximum seasonal catch and an increase in minimum size limit for females. These results may reflect the fact that the management tools in which there was heterogeneity in preferences limit catch indirectly and require some individual reflection on their historical and expected catch rates and sizes. Overall having an acute understanding of fishers' preferences enables managers to account for potential behavioural responses to the management of recreational fisheries.

Overall, this thesis has contributed to the understanding of behaviours and preferences specifically related to compliance and management of recreational fisheries. The research undertaken in this thesis is subject to several caveats and limitations, each of which provides avenues for future research. This thesis finds that there are potential alternative compliance tools for recreational fisheries, with

successful results from a controlled experimental context. There is scope for future research using the findings of Chapters 3 and 4 as a basis to conduct a field experiment with recreational fishers to test the influence of nudges on compliance behaviour. Alternative nudges and cognitive biases that could be used to leverage compliance tools include; altering the status quo and defaults, simplification and framing of messages which builds on the tendency that people rely on the initial information received, as well as changes to physical environment that can act as reminders. Each of these alternatives have potential to increase compliance and the effectiveness of which should be explored and tested. Additionally, while a number of psycho-social characteristics were examined to be related to responses to compliance incentives, we acknowledge there are other factors which may influence the effectiveness of compliance incentives. Other factors that would likely be related to compliance behaviour and effectiveness of compliance incentives are vast. For example, Costa & Kahn (2013) found evidence of varying effectiveness of a social norm nudge for energy conservation depending on political ideology. Previous behaviour and self-perception and the perceived seriousness of the act may also influence decisions to be compliant (Dodd 2018).

Within this thesis we focussed on behavioural incentives in the context of encouraging voluntary compliance. There is scope to apply nudges to encourage other aspects of compliance, such as community based reporting. For example, the impact of social norms or framing of information could be explored and tested for effectiveness at encouraging others to report non-compliant acts. While this may be applicable for recreational fisheries in which there is less monitoring and enforcement capacity compared to industrial commercial fisheries, it may also be relevant in countries where there are coastal exclusions for small scale operators resulting in minimal monitoring. Within this thesis we measured a one-shot CPR game and a one-time assessment of management preferences. It would be of interest to explore dynamic and continuous contexts or projections to explain how the dynamics of social norm affect compliance behaviour and individual's response to management incentives over a longer time frame. For example, it would be of interest to conduct a network analysis of how social norms spread throughout a population, for example using an agent based model. This would enable the path and projection of social norms to be modelled and a measure of the associated changes in compliance, or behaviour, or perception.

Together this thesis highlights several drivers of heterogeneity within recreational fishing management. This thesis explored the opposing responses to compliance incentives, from consistently compliant or consistently non-compliant as well as those who improve behaviour or act counterintuitively. These responses are not random and it is useful to explore the drivers of them. For

example, this thesis highlighted that risk, personality, and perceptions are related to compliance responses. Finally, this thesis explored if fishing characteristics, such as avidity or fishing method could account for management preferences to give insights in to the heterogeneity within a fisher population. This type of improved understanding of fishers heterogeneity can reduce unintended outcomes of management interventions (Pine et al. 2009) and better predict and assist how recreational fisheries adapt and evolve to maintain resilience and sustainability on a global scale (Arlinghaus et al. 2013). The results of the research within this thesis provide empirical evidence of alternative compliance tools, such as nudges as well as drivers of different behaviours and opinions. The findings underline the importance of nuance and heterogeneity of fishers, behaviours, and drivers in the context of recreational fisheries. Knowledge of this variability encourages better integration of accurate human dimensions and can advance recreational fisheries towards innovation and increased effectiveness.

Thesis Appendix: Additional publications during PhD

Kelly, R., Cottrell, R., **Mackay, M**., Rousseau, Y. 2017, *Book review: Perspectives on oceans past: A handbook of marine environmental history* - Kathleen Schwerdtner Máñez. Reviews in Fish Biology and Fisheries. 27:285 https://doi.org/10.1007/s11160-016-9462-x

Abstract:
No marine area is unaffected by human influence (Halpern et al. 2008) nonetheless editors Kathleen Schwerdtner Máñez and Bo Poulsen highlight in their recent book how very limited our understanding of the ocean and our long-established interaction with the marine realm is: 'The interaction of humans with the sea is a long story, of which not all has been told'. The book is a review and appraisal of a variety of methods and techniques that have been used to evaluate historical human interaction with the marine realm, exploring approaches for investigation across multiple disciplines. Discussions in this interdisciplinary book traverse archaeology, human archives, oral accounts, gender perspectives, and ecological models and indicators as important tools for understanding long-term human interactions and impacts on marine systems.

Cvitanovic, C., Van putten,E., I., Hobday, A., **Mackay, M**., Kelly, R., McDonald, J., Waples, K., Barnes, P. 2018, *Building trust among marine protected area managers and community members through scientific research: Insights from the Ningaloo Marine Park, Australia.* Marine Policy. 93: 195-206 DOI https://doi.org/10.1016/j.marpol.2018.04.010

Abstract:
The success of participatory marine governance arrangements is influenced by the levels of trust that exist between decision-makers and diverse stakeholder groups within the community. While the benefits of high levels of trust among these groups is well established, specific approaches to building trust remain largely unknown. The aim of this study is to understand the extent to which scientific research programs can enhance trust among marine protected area (MPA) managers and community members via an evaluation of the Ningaloo Research Program - a large-scale program of marine research in the Ningaloo Marine Park. Results from a survey of 125 local residents show that community members along the Ningaloo coast believe that scientific research is important for the management of the marine park, and strongly support government investment in scientific research in the region. Results also suggest that science undertaken through the Ningaloo Research Program has increased the extent to which community members trust local managers, which study participants believe has led to improved social and environmental outcomes in the region. Finally, additional opportunities are identified to maintain and further enhance trust between community members and MPA managers, via targeted communication and engagement programs that account for different personality 'types'. In particular, the establishment of citizen science programs might further build trust. These results suggest that scientific research could be used as a means to increase trust among decision-makers and community members when coupled with an effective communication and outreach program, thus enhancing the success of participatory marine governance arrangements.

Kelly, R., **Mackay, M**., Nash, K. L., Cvitanovic, C., Allison, E. H., Armitage, D.A., Bonn, A., Cooke, S. J., Frusher, S., Fulton, E., Halpern, B., Lopez, P., Milner-Gulland, EJ., Peck, P., Pecl, G., Stephenson, R., Werner, F., 2019, *Ten tips for developing interdisciplinary socio-ecological researchers*. Socio-Ecological Practice Research DOI https://doi.org/10.1007/s42532-019-00018-2

Abstract:
Interdisciplinary research and collaborations are essential to disentangle complex and wicked global socio-ecological challenges. However, institutional structures and practices to support interdisciplinary research are still developing and a shared understanding on how best to develop effective interdisciplinary researchers (particularly at early career stages) is lacking. Barriers to interdisciplinary approaches, which include diverse disciplinary 'languages', research time constraints and limited guidance on how to achieve interdisciplinarity in practice, further challenge this understanding. To help overcome these barriers, this paper provides practical advice for early career researchers and their mentors, as well as senior researchers and lab leaders, in the form of 10 tips: '*Develop an area of expertise '; 'Learn new languages '; 'Be open -minded '; 'Be patient '; 'Embrace complexity '; 'Collaborate widely ; 'Push your boundaries '; 'Consider if you will engage in interdisciplinary research '; 'Foster interdisciplinary culture* '; and *'Champion interdisciplinary researchers '*. They are presented here to empower present and future generations of interdisciplinary researchers in their endeavour to solve contemporary socioecological challenges worldwide.

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